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WE GUARANTEE that of this issue more than 9,200 copies were printed; that of those more than 9,200 copies, 7,048 were mailed to regular paid subscribers, 200 were provided for counter and news companies' sales; and 1,700 were printed for distribution at Atlantic City and for use as sample copies.

J. SNOWDEN BELL'S paper on three-cylinder locomotives is an historical review of some of the more noteworthy engines of that class. The discussion was brief, presumably because of the lack of experience of the members with that class of motive power. But from what was said, in discussion as well as from the contex and of the paper itself, it appears that the design has much to recommend it, both on the basis of uniformity of turning movement and increased tractive effort without encroaching on the clearance space, as would be done by an increase of cylinder diameter with a two-cylinder machine. The fact that the Philadelphia & Reading has a number of engines of Mr. Taylor's design in satisfactory operation, and that the Midland of England has over a hundred of the Smith locomotives in service and finds that they effect a coal saving as compared with the ordinary locomotive, indicates that there is a basis for the claims of those who are advocates of this design.

IT has been suggested before in these columns that it would be to the advantage of all concerned if the American Society for Testing Materials would keep in a somewhat closer touch with the members of the mechanical associations, before adopting specifications which the latter are to use. This is exemplified, in a small way, by the report on specifications for materials used in locomotive construction, which is merely a report on boiler tube specifications. The specifications of the Society for Testing Materials are not acceptable, as they stand, to the Master Mechanics' Association. Hence, they have been revised, and now it will be necessary for the Society for Testing Materials to either blindly adopt the specifications that were sent to letter ballot yesterday or issue those to which no one will pay attention or use. It emphasizes the necessity of co-ordinating the work of the two associations in the same way that has been done by the Master Car Builders' and the Master Mechanics' Associations, if satisfactory and acceptable specifications are to be obtained.

IT is rather staggering, this talk of a cast iron wheel for tenders of 140,000 lbs. capacity, when we remember how few years ago it was that the car of 60,000 lbs. capacity was thought to be the last word in big cars. The problems involved in the use of such a wheel load, using, as it does, 23,000 lbs. or so per wheel, are by no means easy of solution. Dr. Dudley's suggestion that the coning of the standard wheel is too sharp and throws an excessive load on the inside of the rail head is but one of the points involved. And though the relation of the wheel and rail has been the subject of constant attention ever since the publication of M. N. Forney's historic paper on the subject before the Master Car Builders' Association in the eighties, the question has not yet been settled. And now, with these heavier loads, the cast iron wheel makers are asking for another eighth of an inch of guard rail spacing in order to permit of strengthening the flange. This request has the support of many car builders and, if it is granted, will give a new lease of life to the cast iron wheel. On the score of safety it seems quite feasible to adopt this wider spacing, and it remains to be seen whether or not the American Railway Association will grant the request should the Master Car Builders' Association decide to formally prefer it.

THE American Railway Engineering Association, which meets at Chicago each year during March, conducts its meetings in a way which might be studied with profit by members of the Master Mechanics' and Master Car Builders' Associations. In the first place, the reports are published in the association bulletins which are issued during the year, thus giving the members ample opportunity to thoroughly check over and digest them before the annual meeting. When a report is called for at the convention all the members of the committee, and there are usually eight or ten of them, go to the platform and seat themselves behind a long table which extends practically the full width of the platform. As the convention attendants are all supposed to be familiar with the report the Chairman does not attempt to present it in detail, but places it before the convention with a few brief introductory remarks, unless he has additional information to present which was not incorporated in the printed report. It is then open for discussion, and as various questions or criticisms are brought up, they are referred to the member of the committee who is best able to answer or reply to them. The sight of the committee seated in a long row on the platform is impressive, and one cannot but be struck by the businesslike and earnest way in which the meetings are conducted.

IN view of the general character of the replies to the series of questions sent to the railroads by the committee on the Use of Special Alloys and Heat-Treated Steel in Locomotive Construction it would seem that the convention acted wisely in continuing the committee. The subject is a broad one and while it seems to be the concensus of opinion that the association should have such specifications, the actual preparation of these can well be continued for another year at least in order that the results of further experiments and service may be utilized. Although the discussion of the report was quite limited, it brought out the fact that the use of heat-treated carbon steel in axles has not always produced desirable service results. The Chicago, Milwaukee & St. Paul reported very unsatisfactory service from such axles used under 200 locomotives; on planing down the axles that had failed it was found that cracks began to develop about four inches from the surface and that beyond that the metal could be fractured with great ease. On the Central of Georgia a number of axles failed after from four to six weeks service. In view of these facts it would seem desirable that some steps be taken to determine the cause and remedy

for the trouble and it is probable that the committee has this in mind. The report also brought out the fact that vanadium is being extensively used in locomotive frames.

AFTER all that has been said and written on the subject of smoke abatement and the numerous devices that have been applied to locomotives to prevent the making of black smoke, it is gratifying to learn from the report of the committee on Smoke Prevention that such a simple procedure as the injection of air into the firebox by means of steam jets solves the problem. It was brought out in the discussion of the report that the idea is not a new one, but it is nevertheless so effective that a large number of locomotives operating in the city of Chicago are now equipped with the necessary apparatus and the chairman of the committee, E. W. Pratt of the Chicago & North Western, stated that no one need have the least apprehension about the failure of the jet system to abate the smoke on any locomotive to which it is applied. While the fact of smoke abatement in itself demonstrates that there is more complete combustion, it is particularly interesting to learn that apparently the steam-jet tubes reduce the weight of sparks discharged from the stack and that there is an increase in the equivalent evaporation and a corresponding increase in economy. It was also brought out that the use of the brick arch gave an increase in evaporation of about 8.6 per cent., but the steam jets increase the equivalent evaporation whether a brick arch is used or not.

TESTS WITH SUPERHEATED STEAM.

IN some respects, the appendix to the report of the committee on superheater locomotives, which gives the results of an elaborate series of comparative tests made with otherwise exactly duplicate locomotives, one having a Schmidt superheater and the other without a superheater, on the locomotive testing plant at Altoona, is the most valuable contribution to the proceedings of the Association that has been offered for many years. It forms a book of 192 pages and includes over 100 charts and 30 tables. Conclusive results are given on several features of locomotive design over which there has been considerable difference of opinion. The saving of coal and water by the use of superheated steam is about what has been shown by other tests and by regular service. The increase in the capacity of the locomotive by the application of a superheater has also been generally understood, but it is doubtful if its amount has been fully appreciated. On the other hand, the temperature at various points in the tubes, the most desirable ratio of tube length to its diameter, the pressure and temperature at various points in the path of the steam throughout its course from the throttle to the cylinders, the most desirable point of cut-off, the proper relation of the diameter of the cylinders, the effect of throttling and a number of other similar questions are here, for the first time, answered with confidence.

One of the most interesting results of these tests is the amount of power it is possible to obtain from an Atlantic type locomotive using superheated steam. To be sure this is an exceptionally heavy locomotive, much heavier than could be used on most roads, but it comes as a surprise to find that over 2,200 indicated horsepower can be obtained with a locomotive of this type. Furthermore, the water rate, or pounds of steam used per indicated horsepower hour, at the higher powers is a record for locomotive practice. At 84.4 miles an hour, when the locomotive had an indicated horsepower of nearly 2,000, the water rate was 15.81 lbs. At 1,360 horsepower the minimum coal consumption of 2.29 lbs. per indicated horsepower hour was obtained.

For the conditions on the Pennsylvania a ratio of 100 between the diameter and length of the tubes is recommended, although it is pointed out that the most desirable length of tube depends on how much the designer is willing to sacrifice in boiler efficiency to obtain rapid evaporation. The temperature investigations throughout the length of the tubes showed that there is a rapid drop for a distance of three or four feet from the firebox end, after which the drop is much more gradual until the curve becomes flat toward the smokebox end. There is also a large drop between the temperature of the firebox and just inside the end of the tubes. Firebox temperatures from 2,000 to 2,400 degrees were obtained, while the maximum temperatures in the tubes was from 1,370 to 1,620 degrees. The location of the tube in the boiler has little influence on the temperature. Those at the bottom are as hot as those at the top. The superheater flues were uniformly from 100 to 200 degrees hotter than the tubes, due to the larger volumes of gases passing through them.

The drop in pressure between the boiler and the branch pipe increases regularly with the increase in power and did not exceed 14 lbs. at the maximum. This difference, however, is largely offset by the accompanying increase in steam volume resulting from the increase in superheat and the corresponding decrease in the heat supplied to the cylinders per stroke. At the front return bend of the superheater under conditions of maximum steam flow there is a drop of 4.2 lbs.

An increase in the output of the boiler is accompanied by a direct increase in the amount of superheat in the branch pipe. At horsepowers above 700 there was found an increase of approximately one degree for each increase of 15.3 indicated horsepower. In connection with the finding, however, the report draws attention to other factors which might alter it when applied to other locomotives. It is also shown that the amount of superheat cannot be increased at a given cut-off without an increase in speed. An investigation of the back pressure develops that, for the same work done, superheated steam exhausts with less than half the least back pressure with saturated steam.

Attention was drawn by Mr. Vaughan to two most interesting sets of curves given in the report. These show the coal and steam consumption at various horsepowers for both locomotives and indicate the economy and increased capacity in a striking manner. The fuel consumption at power below 500 horsepower shows little difference in the two locomotives, but from that point the consumption on the saturated locomotive rises very rapidly until it reaches over 5 lbs. at 1300 horsepower, which is the limit of capacity of this locomotive. The consumption in the superheater locomotive, on the contrary, is well below 3 lbs., up to 1400 horsepower, and does not reach 4 lbs. at 1800 horsepower. As regards steam consumption it is shown that one of the causes for the limitations of the saturated locomotive is the increase in the water rate at the higher powers. The contrary is true with superheated steam and it continued to decrease up to the limit of capacity of the locomotive.

From this data conclusions are drawn that the application of the superheater increased the economy of this locomotive from a minimum of 12 per cent. to a maximum of 40 per cent., and that, in addition, a capacity of 30 per cent. greater can be obtained beyond the capacity when using saturated steam. The increase in capacity is about the same as the theoretical increase in the volume of the steam in the two cases. It is the 30 per cent. less weight of steam used which in a large measure is believed to account for the economy, as it results in a smaller amount of heat being discharged through the exhaust. A smaller total quantity of heat is supplied and a larger percentage utilized.

The report states that it would seem logical from these economies in water and fuel, that any locomotive which is being converted from a saturated to a superheated steam locomotive should have enlarged cylinders so long as the proper coefficient of adhesions is not exceeded. Such a locomotive will maintain its steam pressure through a wider range of power and there will be less chance of insufficient steam supply at the highest speeds.

TO-DAY'S AND SUNDAY'S PROGRAMS.

SATURDAY, JUNE 14.

Orchestra Concert, 10.30 A. M.—Entrance Hall, Million Dollar Pier.

Orchestra Concert, 3.30 P.M.—Entrance Hall, Million Dollar Pier.

SUNDAY, JUNE 15.

Concert, 11.00 A.M.—Marlborough-Blenheim Hotel Orchestra Jacques Kinsbergen, musical director: Prelude and Intermezzo from Cavalleria Rusticana (*Mascagni*); (A) Ave Maria (*Gounod*); (B) Mighty Lake Rose (*Nevin*); Andante Religiosa (*Thome*); 'Cello Solo; Norwegian Folk Song (*Ole Bull*); Mr. Carl Johner; Serenade, Le Millions D'Arlequin (*Drigo*); Dreams (*Wagner*); (A) There is a Green Hill Far Away (*Gounod*); (B) Pastoral Dance (*German*); Fantaisie Lohengrin (Wagner).

Concert, 8.45 P.M.—Overture Mignon (*Thome*); Piano Solo, A Flat Major Polonaise (*Chopin*); Mr. Joseph Lanin, Fantaisie, La Boheme (*Puccini*); Violin Solo, Gypsy Airs (*Sarasate*), Mr. Jacques Kingsbergen; Cansette (*Schindler*); 'Cello Solo, Antante Cantabile (*Cui*); Fantaisie Faust (*Gounod*).

CONVENTION OF RAILWAY ELECTRICAL ENGINEERS.

The semi-annual meeting of the Association of Railway Electrical Engineers will be held in Atlantic City, June 16, at the Dennis Hotel.

ANNUAL MEETING R. S. M. A.

The annual meeting of the Railway Supply Manufacturers' Association will be held in Convention Hall this morning at 10:30 to elect officers and transact any other business that may come before the meeting.

MUSICALE.

An instrumental and vocal concert was given at the entrance ball of the Million Dollar Pier last evening, by Eugene Engel's orchestra. The committee in charge was composed of Messrs. Sherman (chairman), Toothe, Crowe, Nealley, Sheridan, Chaffee, Fettinger and Landreth.

PURDUE DINNER.

The annual dinner of Purdue men at the convention will be held at the Shelburne Hotel this evening at 6.30. Dean Benjamin and Prof. Endsley will be present and a large number of Purdue men have already signified their intention of attending. All Purdue men are requested to register at the booth of the *Railway and Engineering Review.*

B. & O. CLUB.

The annual meeting of the B. & O. Club will be held in the Park Place hall of the Marlborough-Blenheim hotel at 3.30 p. m. next Monday afternoon, June 16. The hall is on the Blenheim side of the hotel, one can be reached by entering that side, and turning to the right.

The first meeting of the club, called for the purpose of organizing it, was held during the conventions last year. All present or former employes of the Baltimore & Ohio attending the conventions, whether the mechanical department or not, are eligible to membership.

C. F. Giles, superintendent of machinery of the Louisville & Nashville, was elected president and C. L. Sullivan, sales manager of the Cowles-McDowell Engineering Company, secretary last year. A committee composed of S. M. Dolin, American Car & Foundry Company, A. Gordon Jones, General Railway Supplies, and J. Snowden Bell, was appointed to draft a constitution and by-laws. This committee will present its report for action Monday; and officers for the next year will be elected The transaction of business will be followed by a social time.

SUPPLY ASSOCIATION DISTRICT ELECTIONS.

Results of the district elections held Friday for members of the executive committee of the Railway Supply Manufacturers' Association were as follows:

Second district (New York and New Jersey)—C. B. Yardley, Jr., Jenkins Bros. and J. C. Currie, Nathan Manufacturing Company.

Fourth district (Ohio, Indiana and Michigan)—C. F. Elliott, Acme White Lead & Color Works.

Fifth district (Illinois, Wisconsin, Iowa and Minnesota)—Joseph H. Kuhns, Republic Rubber Company.

SOCIETY OF RAILWAY CLUB SECRETARIES.

This paragraph is a reminder to officers of railroad clubs and others that the Society of Railway Club Secretaries has an informal luncheon today at 12.30 P. M. at the Hotel Strand. No invitations have been issued, and the secretaries will be glad to welcome around the board all of their friends who have the time and inclination to participate. The luncheon takes the place of the annual dinner of former years to accommodate those whose time is much taken up in the evening with engagements.

Preceding the luncheon the secretaries will have their annual business meeting in Apartment 5 of the Marlborough-Blenheim.

M. K. BARNUM GOES TO THE BALTIMORE & OHIO.

M. K. Barnum, general superintendent of motive power of the Illinois Central, will go to the Baltimore & Ohio on July 1, to take the office of general mechanical inspector of that road. Thus Mr. Barnum once more becomes associated with Daniel Willard, president of the B. & O., and F. H. Clark, its general superintendent of motive power. When Mr. Willard was vice-president of the Burlington and Mr. Clark superintendent of motive power, Mr. Barnum was general inspector of machinery and equipment of that road, reporting direct to the vice-president.

Mr. Barnum is so well known to those attending the conventions as to make superfluous mention of his many admirable qualities personally and as a railway officer. He first entered railway service on the Erie, and was successively machinist, mechanical inspector and general foreman of that road. He was later assistant master mechanic of the Santa Fe at Argentine, Kan.; superintendent of the Union Pacific shops at Cheyenne, Wyo., and district foreman and division master mechanic of the same road. He has served since then as assistant mechanical superintendent of the Southern, as superintendent of motive power of the Rock Island, in the capacity already mentioned on the Burlington, and as general superintendent of motive power of the Illinois Central.

Mr. Barnum returned to Atlantic City yesterday from New York, where he conferred with President Willard.

LACK OF RAILWAYS IN CHINA.—Neither the province of Kwangsi nor that of Kweichow nor the section of Yunnan supplied by Wuchow has any railways. The existence of a Kwangsi provincial railway company is made known whenever any suggestion is made that foreign capital be employed to build railways in the province; further than that, however, it has accomplished nothing to date. Three lines of railway for Kwangsi have been projected by the Ministry of Posts and Communications, but no one of them has as yet progressed beyond the projected stage.

MASTER MECHANICS' ASSOCIATION PROCEEDINGS.

Reports on Superheaters, Three-Cylinder Locomotives, Heat-Treated Steel, Smoke Prevention, Tender Wheels.

President Crawford called the third session to order at 9.30 a. m. Friday morning.

SPECIFICATIONS FOR MATERIALS USED IN LOCOMOTIVE CONSTRUCTION.

After conferring with subcommittee X of the American Society for Testing Materials, the specifications which follow have been prepared covering lap-welded and steel boiler tubes. These specifications do not differ greatly from those of the American Society for Testing Materials. They have, however, been amplified by including arch tubes and the large superheater tubes, instead of being confined to tubes of 2½ in. in diameter and less. The paragraph describing the method of making the flange test has been introduced, and some other changes of a minor nature made.

The report is signed by:—W. C. A. Henry (Penna.), chairman; H. T. Bentley (C. & N. W.); H. E. Smith (L. S. & M. S.); Frank Zeleny (C. B. & Q.), and A. G. Trumbull (Erie).

Specifications for Lap-welded and Seamless Steel Boiler Tubes, Safe Ends, and Arch Tubes.

MANUFACTURE.

1. The steel shall be made by the open-hearth process.

CHEMICAL PROPERTIES AND TESTS.

2. The steel shall conform to the following requirements as to chemical composition.

Carbon	0.08—0.18 per cent.
Manganese	0.30—0.50 per cent.
Phosphorus	not over 0.04 per cent.
Sulphur	not over 0.045 per cent.

3. (a) Analyses of two tubes in each lot of 250 or less may be made by the purchaser, which shall conform to the requirements specified in Section 2. Drillings for analyses shall be taken from several points around each tube.

W. C. A. HENRY,

Chairman, Committee on Specifications for Materials Used in Locomotive Construction.

(b) If the analysis of only one tube does not conform to the requirements specified, analyses of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

PHYSICAL PROPERTIES AND TESTS.

4. (a) A test specimen not less than 4 in. in length shall have a flange turned over at right angles to the body of the tubes without showing cracks or flaws. This flange as measured from the outside of the tube shall be ⅜ in. wide for tubes 2½ in. or less outside diameter, and ½ in. wide for tubes larger than 2½ in. outside diameter.

(b) In making the flange test, it is recommended that the flaring tool and die block as shown he used.

5. A test specimen 4 in. in length shall stand hammering flat until the inside walls are in contact, without cracking at the edges or elsewhere. For lap-welded tubes, care shall be taken that the weld is not located at the point of maximum bending.

6. A test specimen 2½ in. in length shall stand crushing longitudinally until the outside folds of metal are in contact, without showing cracks or flaws.

7. Tubes under 5 in. in diameter shall stand an internal hydraulic pressure of 1,000 lbs. per sq. in. and tubes 5 in. in diameter or over, an internal hydraulic pressure of 800 lbs. per sq. in.

8. (a) Test specimens shall consist of sections cut from tubes selected by the inspector representing the purchaser from the lot offered for shipment. They shall be smooth on the ends and free from burrs.

(b) All specimens shall be tested cold.

9. One flange, one flattening and one crush test shall be made from each of two tubes in each lot of 250 or less. Each tube shall be subjected to the hydraulic test.

10. If the results of the physical tests of only one tube from any lot do not conform to the requirements specified in Sections 4, 5 or 6, retests of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

STANDARD WEIGHTS.

11. The standard weights for tubes of various outside diameters and thicknesses are as follows:

Outside Diameter.	Thickness (Inches).						
Inches.	.095 Pounds.	0.110 Pounds.	0.125 Pounds.	0.135 Pounds.	0.150 Pounds.	0.165 Pounds.	0.180 Pounds.
1.75	1.68	1.93	2.17	2.33	2.56	....	....
2.00	1.93	2.22	2.50	2.69	2.96	....	....
2.25	2.19	2.51	2.84	3.05	3.36	....	....
2.50	2.44	2.81	3.17	3.41	3.77	4.09	4.41
3.00	....	3.40	3.84	4.13	4.57	4.93	5.36
3.50	....	....	4.51	4.85	5.37	5.81	6.31
4.00	....	....	....	5.57	6.17	6.76	7.26
4.50	....	....	....	....	6.97	7.64	8.30
5.00	....	....	....	....	7.77	8.52	9.27
5.25	....	....	....	....	8.17	8.96	9.75
5.375	....	....	....	....	8.37	9.18	9.99
5.50	....	....	....	....	8.57	9.40	10.23
6.00	....	....	....	....	9.37	10.28	11.19

12. The weight of the tubes shall not vary more than 5 per cent. from that specified in Section 11.

WORKMANSHIP AND FINISH

13. (a) The finished tubes shall be circular within 0.02 in. and the mean outside diameter shall not vary more than 0.015 in. from the size ordered. The thickness at any point shall not vary more than 10 per cent. from that specified. The length shall not be less, but may be 0.125 in. more than that ordered.

14 The finished tubes shall be free from injurious defects and shall have a workmanlike finish. They shall be free from kinks, bends and buckles.

MARKING.

15. The name or brand of the manufacturer and "Tested at 1,000 lbs." for tubes from 0.125 to 0.180 in., thickness of material, or "Tested at 900 lbs.," for tubes less than 0.125 in. thickness of material, shall be legibly stenciled in white on each tube.

INSPECTION AND REJECTION.

16. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tubes ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the tubes are being furnished in accordance with these specifications. All tests except check analyses and inspection shall be made at the place of manufacture prior to shipment unless otherwise specified, and are to be so conducted as not to interfere unnecessarily with the operation of the works.

(a) Tubes when inserted in the boiler shall stand expanding and beading without showing cracks or flaws, or opening at the weld. Tubes which fail in this manner will be rejected and the manufacturer shall be notified.

17. (b) Unless otherwise specified, any rejection based on tests made in accordance with Section 3 shall be reported within five working days from the receipt of samples.

18. Samples tested in accordance with Section 3, which represents rejected tubes, shall be preserved for two weeks from

the date of the test report. In case of dissatisfaction with the results of the test the manufacturer may make claim for a rehearing within that time.

The report was received and referred to letter ballot for adoption as recommended practice.

SUPERHEATER LOCOMOTIVES.

Since the last report there has been an increase in the number of locomotives in the United States and Canada using superheated steam to 8,822, or more than 100 per cent. Reports from the users indicate that they have been uniformly satisfactory. The troubles that were feared with packing and valves, due to the high temperature of superheated steam, have not developed to any great degree, and where there has been any trouble it has been overcome largely, if not entirely, by the use of good material for the parts in question. It is conceded generally that it is necessary to have cylinders, cylinder bushings, valves and valve bushings made of close-grained iron rather harder than is absolutely necessary when using saturated steam, and that iron low in phosphorus and silicon is desirable.

The committee has not been able to determine any definite figure on the comparative cost of maintaining superheated and saturated steam locomotives, but the general concensus of opinion seems to be that the increase, if any, in the cost of maintenance is not going to be of sufficient moment to influence the question one way or the other.

During the year the Pennsylvania Railroad started a series of tests contemplating the comparison of two Atlantic type locomotives, two Pacific and two consolidation locomotives, of modern size, one of each type equipped with Schmidt superheater, and the other using saturated steam. The tests of the Atlantic and Pacific type locomotives have been completed, and copy of report upon the Atlantic type locomotive is given in complete detail as an appendix to this report. The work on the Pacific and consolidation type locomotives is not yet in such shape as to warrant figures being given out, but at least a résumé of the results will be given in next year's report.

The members of the committee concur in the conclusions appended to this test.

The report is signed by:—J. T. Wallis, (P. R. R.), chairman; C. H. Hogan, (N. Y. C. & H. R.); R. W. Bell, (I. C.); Thomas Roope, (C., B. & Q.); W. J. Tollerton, (C. R. I. & P.); H. H. Vaughan, (C. P.), and J. R. Gould, (C. & O.).

[The report of the tests on the Altoona locomotive testing plant on superheater and saturated steam locomotives, which forms an appendix to this report, is too voluminous to be covered here. It will be reproduced more fully in the regular weekly and mechanical editions of the *Railway Age Gazette*. The conclusions of the tests are given below.—EDITOR.]

BOILER.

Previous tests have indicated, and the results obtained with this locomotive confirm the conclusion, that the locomotive boiler surfaces absorb a fixed amount of heat from each cubic foot or from each pound of the gases of combustion flowing past them, and the increase in evaporation is due to the increase in weight or quantity of the gases of combustion, and to no other cause. This being true, the capacity of the boiler is fixed by limitations of combustion upon the grate, and not by a failure of the boiler surfaces to absorb heat.

The limit of boiler capacity with this locomotive was reached at a rate of coal burning of approximately 7000 lbs. per hour, and, therefore, whether or not a stoker is required to efficiently handle this locomotive will depend upon the length of grades to be ascended and the requirements of continual heavy loading.

These tests furnish us with additional information on flue lengths which is of value. The short tubes show an advantage in activity of combustion and also in rapidity of evaporation, with an attending lower efficiency of the boiler, and we conclude that:

(*a*) The most desirable length of tube depends upon how much the designer is willing to sacrifice in boiler efficiency to obtain rapid evaporation with some loss of heat.

(b) There is a rapid decrease of temperature in the tubes for a distance of three or four feet from the firebox end, after which the temperature drop is more gradual until, with this short tube, the curve of tube temperature becomes flat toward the smokebox end, and therefore the heat transfer at the firebox end of this tube is much higher than at the smokebox end.

(*c*) The temperature of the superheater flue is in all cases from 100 to 200 degrees higher than the temperature in the boiler tube. This is probably due to the larger volume of gases passing a hot tube surface, namely, the superheater units.

(*d*) Observations made on other locomotives indicate that there is little if any difference in temperature of flues as far as their location in the sheet is concerned.

(*e*) From the boiler efficiency obtained with this locomotive, the form of the curve of temperature drop in the tubes, and the high smokebox temperature, slightly longer tubes seem desirable.

ENGINES.

For a given cut-off, the water rate decreases with an increase in superheat, the rate of decrease apparently being faster at the shorter cut-offs. For a given water rate the superheat increases with an increase in cut-off, the increase in cut-off causing a higher draft on the fire and an attending increase in power output.

Remembering that 30 per cent. less weight of steam is used when superheating, it is this fact which in a large measure results in a lower amount of heat discharged through the exhaust. A smaller total quantity of heat is supplied and a larger percentage utilized, and therefore an economy is brought about by the reduction of waste heat through the exhaust.

In exhausting steam from a locomotive cylinder it has been found that, for the same work done, less than one-half the least back pressure is required as compared with these cylinders operating with saturated steam.

LOCOMOTIVE.

In Bulletin 19, when discussing the K29 locomotive, conclusion 9 on page 144 was drawn that an economy in water approximately 30 per cent. and in coal of between 20 and 30 per cent. might be expected when using highly superheated steam with a boiler pressure of 200 pounds per square inch. This conclusion is confirmed by these E6's tests, and the additional conclusion seems to be warranted that, when approaching the limit of the saturated steam locomotive, a saving as high as 50 per cent. may be expected, and that the application of the superheater justifies itself by an increased maximum capacity over the saturated steam locomotive of not less than 30 per cent.

If we assume a limit of 1400 dynamometer horse-power for the E6 locomotive, the E6s may be expected to produce 1850 dynamometer horse-power, or an increase of 32 per cent.; this marks the increased power which may be expected by superheating.

The application of the superheater to this locomotive increases its economy from a minimum of 23 per cent. to a maximum of 46 per cent., the economy increasing with the increased power required of the locomotive.

It was found that 30 per cent. higher capacity was derived from the E6s locomotive when using superheated steam than with the same size and type of locomotive using saturated steam.

When conditions are such that the starting of trains, and low speeds up to approximately 30 miles per hour, are not factors in tonnage rating, the application of the superheater to a passenger locomotive permits an increase of rating of approximately 30 per cent. If the starting of heavy trains and low speeds of operation are factors in establishing the tonnage rating, there is nothing in these tests to indicate that the superheater locomotive should have a lower rating than the saturated steam locomotive.

From the results obtained in the tests we believe that any locomotive in being converted from saturated to superheated steam should, with the application of the superheater, have enlarged cylinders, the results indicating that for the purpose of obtaining maximum economy the extent of the cylinder enlargement should be such that the maximum indicated horse-power may be developed at a cut-off not exceeding 30 per cent.

DISCUSSION.

H. T. Bentley, (C. & N. W.): I move that the thanks of the Association be tendered to Messrs. Wallis and Young and the Pennsylvania Railroad for their assistance in giving us this splendid paper. (The motion was carried).

H. H. Vaughn, (Can. Pac.): I think the diagrams showing the coal per dynamometer horse-power hour, and the steam per dynamometer horse-power, calculated with reference to the horse-power, are about the most remarkable illustrations that we have ever had of the gain that is obtained by the attachment of superheater to a locomotive. One of the most remarkable features is the way in which the capacity of the superheater locomotive goes up and the amount of power it can develop, while the saturated steam locomotive comes to an absolute stop at about 1,300 h. p. The curve shows at that point that the engine is simply done, there is no more to it, whereas a superheater steam locomotive of the same size

is still going on and giving increased horse-power as required.

Henry Fowler (Midland Railway, England): Of course, on our side we shall welcome very heartily the free way in which these exhaustive experiments have been presented. It is something that I am afraid we do not develop in the same way on our side of the water, but nevertheless, we shall use them to the same advantage, and we also feel a great indebtedness to the Pennsylvania Railroad, to Mr. Young and also the Master Mechanics' Association. There is one point I would question, and that is when they open the fire-hole door, it appears that the steam pressure went up. I do not know if Mr. Young has any figures to show how the efficiency goes, but it has always been our aim on our side to get the firemen to keep the doors closed, which we believe under ordinary circumstances, is the best condition.

C. D. Young: This is the second application we have made of this principle, and we have noticed the same characteristic when the grate surface is being forced to a burning rate of 135 or 150 lbs. of coal per sq. ft. of grate. With probably 15 in. of draught in the front end, there is an insufficient air-supply through the grate, and therefore it is necessary to supply that air for proper combustion. If the fire door is closed under these high-burning rates with the tremendous draughts, it immediately results in a fall of the steam pressure, due to the failure of the coal to burn. By opening the door wide and permitting the air to pass into the firebox from the door, the pressure is quickly regained. These tests are made for one hour duration, and you can readily understand that under a test of this kind your attention and that of your people is taken up with noting a number of details, and it is impossible to make a close study of the efficiency of the increased quantity of air that comes in at that time. But I am convinced we could demonstrate that our monoxide was running very high until we opened the door, when it would change to dioxide. But these things all happen within five minutes, because if the boiler falls, in steam at 16 lbs. evaporating head, it only takes a very brief time to lose a lb.; and besides, you have little time for your observation.

It is difficult to make an examination of the firebox under conditions of this kind. The box is incandescent, due to the depth and the brilliancy of the fire; and the introduction of the air gives a black cone from the point of entry, indicating quite clearly what it is. There is so much air in the inside of the box that I question very much whether under these forced firing rates, there is any drop in the temperature due to the admission of the cold air. It should be remembered, too, that under these conditions, the evaporation is high—above 14 and 15 lbs. of water to the square ft. of heating surface. The thickness of fire was about 18 in. at the door, to 10 in. at the flue sheet, sloping.

THREE-CYLINDER LOCOMOTIVES.

By J. Snowden Bell.

The three-cylinder locomotive, although originated as early as 1846, and applied in railroad service in 1847, has been confined to a smaller range of actual practice than any other design which differs from the standard two-cylinder construction, and the record of its performance may, perhaps, be considered too limited to determine, with reasonable probability of correctness, whether its advantages are sufficient to recommend its general adoption. It does not, however, involve any error in mechanical principle, nor appear to have indicated objections in practice, and seems to the writer to be of sufficient interest and probable value to warrant a more careful and thorough consideration by locomotive designers and users than it has heretofore received.

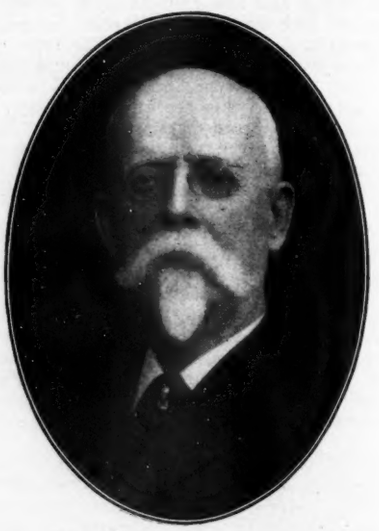
[A historical sketch of the origin and development of three-cylinder locomotives, starting with that developed by Robert Stephenson and William Howe in 1846 down to and including those built from the designs of Howard D. Taylor for the Philadelphia and Reading in 1909, was then presented by the author, many illustrations being included. An abstract of the remainder of the paper follows.—Editor.]

A design for the application of three cylinders in a locomotive of the Mikado type, proposed by H. S. Vincent of the American Locomotive Company, is illustrated in Fig. 1. The central cylinder is set in advance of the two outside cylinders, on an incline of 8 degs., and its piston is coupled to the pin of a crank on the second driving axle. In order to minimize the inclination of this cylinder, the middle portion of the front driving axle is bent slightly into crank form. The pistons of the outside cylinders are coupled to crank pins on the wheels of the third driving axle. The crank pins are set 120 degs. apart. All cylinders are of the same diameter (23 in.) and the main rods are all of equal length (10 ft. 6 in.). The valve chest of the central cylinder is located on its right-hand side, and is readily accessible, as are also the cross head and guides.

The characteristic feature of novelty of this design consists in a construction of valve gear devised by Mr. Vincent, which operates on a principle which appears to be new, viz.: The actuation of the distribution valves of the central cylinder by what is termed a selector lever, the ends of which are connected to and derive motion from the gears which actuate the valves of the outside cylinders. The resultant motion imparted to the middle of this lever is transmitted to the distribution valve of the central cylinder through rocker arms proportioned to give this valve the same steam distribution action as those of the valves of the outside cylinders. This arrangement will be understood by reference to Fig 2, and its simplicity is obvious, no independent link, eccentric, or other analogous valve actuating element being required, as the central valve is moved, controlled, and reversed by the same mechanism as the valves of the outside cylinders, through its connection therewith by the selector lever.

Except as to the application of three cylinders and the means for actuating the valve of the central cylinder without an independent valve gear, as above described, the locomotive of this design is of the present standard Mikado type, and is calculated to be of equivalent power to one having two 28-in. cylinders. Its general dimensions are the following: cylinders, 23-in. diameter and 28-in. stroke; boiler, minimum diameter, 84 in.; tubes, 238 of 2½ in. diameter, and 40 of 5½ in. diameter, 20 ft. 6 in. long; heating surface, tubes, 4,038 sq. ft.; heating surface, fire box, 310 sq. ft.; grate area, 66.5 sq. ft.; tractive power, 60,600 lbs.; weight of engine, total, 332,000 lbs.; weieght on driving wheels, 248,000 lbs.

The high power and speed requirements of modern service have



J. SNOWDEN BELL,
Paper on Three Cylinder Locomotives.

developed the Mallet and Mountain type locomotives, weighing up to 540,000 and 331,500 lbs., respectively, the weights per axle being so great that, in many cases, rails and bridges are strained nearly to the limit of their capacity, and cylinder dimensions being also increased up to the limit of the clearance of some railroads and beyond that afforded on others. As stated to the writer by a locomotive designer of acknowledged high standing and ability, "we have about reached, especially in some of the large Mountain designs, the possibilities of a two-cylinder engine." The destructive effect upon the rails, which increases with the speeed resultant upon the unbalanced vertical force in two-cylinder engines, has long been recognized, and there being apparently no effective means available for neutralizing this effect, there has resulted the arbitrary limitation of static weight per axle to that which, when augmented by the dynamic effect of the excess balance, will not be above that which can be safely carried by the rails and bridges. This limit varies on different railroads, as affected by the solidity of the roadbed and by local traffic conditions.

The most important advantage claimed for the three-cylinder locomotive is the attainment of substantially uniform turning moment, from which there results more rapid acceleration in starting and greatly increased smoothness and steadiness in running; reduced destructive action on rails and bridges; and the exertion of greater tractive power and utilization of a lower factor of adhesion than a two-cylinder engine. The system further affords facilities for providing increased cylinder power, equally divided in a balanced application, at a minimum cost of construction and maintenance, and is adapted for opera-

tion upon the simple, compound, or triple-expansion principle. The necessity of using a crank axle and connections, for the attainment of these results, of course, involves the objection of increased complication and cost, but with the materials and methods now available in the manufacture of crank axles, the objections to this form of driving axle, as compared with a straight axle, are reduced to a minimum, and, as compared with four-cylinder locomotives, a considerable number of which have been constructed, both in Europe and in the United States, the advantage, in point of simplicity and economy, is obviously materially in favor of the three-cylinder locomotive. This is also the case as to structural considerations, there being sufficient space between the frames to provide crank cheeks of ample width, and by reason of its comparatively simple form, the axle can be readily forged in an ordinary railroad shop.

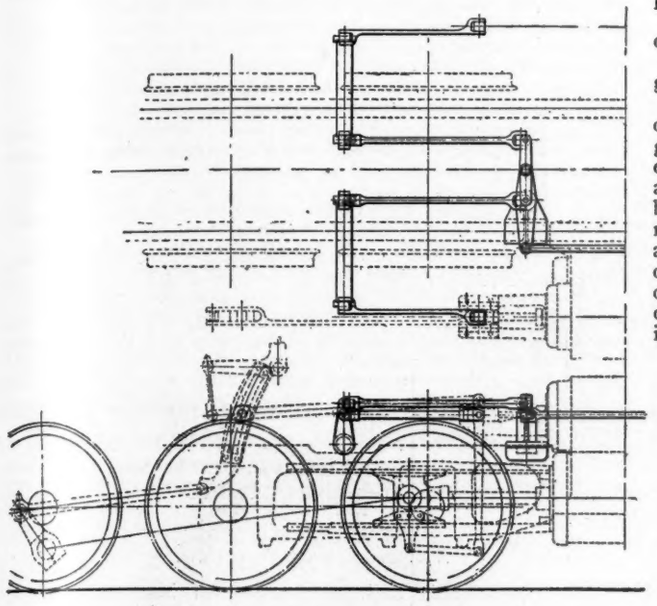


Fig. 2—Valve Gear of Proposed Three Cylinder Locomotive.

When comparing the difference in dynamic effect on the rail of a modern two-cylinder Mikado type locomotive and an equivalent three-cylinder engine of the same power and type, at a speed of 40 m.p.h., it will be found that at this speed the vertical effect of the unbalanced force for the two-cylinder engine is 8,380 lbs. per wheel, or 67,000 lbs. for the engine, thereby causing a difference in rail pressure of 134,000 lbs. in each evolution of the driving wheels, and while the normal static weight of this engine on driving wheels is 243,000 lbs., at a speed of 40 m.p.h., the effect on the rail becomes equal to a static weight of 310,000 lbs.

With the three-cylinder engine, in which the tractive power and nominal driving wheel weights are identical with the two-cylinder engine, there being no unbalanced weight and consequently no vertical dynamic effect, it would seem entirely possible to operate this engine on a much lighter rail than the two-cylinder engine; or, if the latter requires a rail weighing 100 lbs. per yard, the former can be carried safely on $\frac{243000 \times 100}{310000}$ = 80-lb. rail. If the same weight of rail be maintained, the power and weight on driving wheels of the three-cylinder engine can be increased $\frac{310000 - 243000}{243000}$ = 27.6 per cent., without any greater destructive effect on the rail.

At a speed of 45 m.p.h. a comparison of the turning moments of three-cylinder and two-cylinder engines, the two-cylinder engine having cylinders 28 by 28 inches, and the three-cylinder engine having cylinders 23 by 28 inches, both engines having approximately the same power, show that the curve of combined turning moment for the two-cylinder engine reaches its maximum at a crank angle of about 37 degs., and its minimum at an angle of about 80 degs., with a variation in turning moment of 26,000 lbs. With the three-cylinder engine the maximum occurs at 60 degs., 180 degs., and 300 degs., the minimum at 90 degs., 210 degs., and 330 degs., the difference between the maxima and minima being about 9,000 lbs. This increased uniformity of turning action is clearly beneficial in lessening the racking effect due to sudden and violent reversals of strain in the machinery of the locomotive.

At the instant of starting, or for the first few revolutions when the maximum tractive power is being exerted, the maximum combined turning moment of the two-cylinder engine occurs at a crank angle of 45 deg., while at 85 degs. it has nearly reached its minimum, the total variation in one revolution being about 56,000 lbs., and a variation of 54,000 lbs. occurring while the cranks are turning through an angle of 40 degs. In the three-cylinder engine of equal power the curve of total turning moment exhibits the same characteristics as before; that is, the maxima and minima occur at three points in the crank circle, the amount of variation being 26,000 lbs. It should be borne in mind that these rotative curves represent the steam force only. When moving at high speeds, they would be modified somewhat by the inertia of the reciprocating weights.

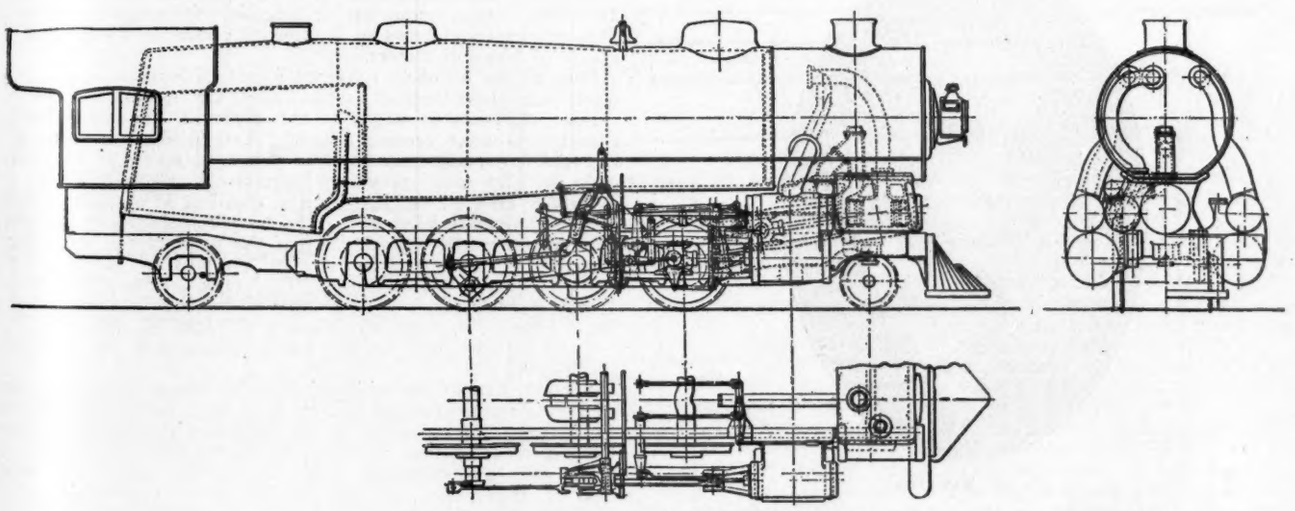


Fig. 1—Proposed Three Cylinder Locomotive.

In the first case the maximum combined turning moment equals 150,400 lbs., and in the second, 131,700 lbs. Slipping will, of course, occur at that point in the stroke where the turning moment is a maximum. Therefore, for the two-cylinder engine, the instantaneous tractive power at the point of maximum turning moment = $\frac{150400 \times 28}{56}$ = 75200 lbs. And the

factor of adhesion $= \frac{243000}{75200} = 3.23$. For the three-cylinder engine the maximum tractive power $= \frac{131700 \times 28}{56} = 65850$ lbs. and the factor of adhesion $= \frac{243000}{65850} = 3.68$. It is therefore entirely feasible in a three-cylinder engine of the proportions mentioned, to increase the tractive power $\frac{3.68 - 3.23}{3.23} = 14$ per cent., with no greater liability to slip the wheels than in the less powerful two-cylinder engine having the same weight on driving wheels. This capability permits the designer to take advantage of the increased boiler capacity obtainable on account of the higher rail loads permissible with this type of locomotive.

DISCUSSION.

Henry Fowler (Midland Railway, England): We have 45 three-cylinder compound engines, working perfectly satisfactorily, at 220 lb. pressure, and as compared with our simple engines on similar work. I fancy the gain we have had in coal consumption has been 7 per cent. I would like to say that the Great Central Railway of England has built one of these engines which operates as a switching engine, which works on a hump, and the Northeasternu Railroad Company has in service a considerable number of 3-cylinder superheater engines. The difficulty, of course, with us, is that we have not the room to put the big cylinder on the side, and have to put it in between. I take it that you also will have to come to something of that kind.

A vote of thanks was given Mr. Bell for his paper.

SPECIAL ALLOYS AND HEAT-TREATED STEEL IN LOCOMOTIVE CONSTRUCTION.

The committee sent out a circular of inquiry outlining a series of seventeen questions. Replies were received from twenty-six railroads, which cover an ownership of approximately 25,266 locomotives. From the information received and that which has been in the possession of the committee, it was decided to only make a progress report.

A few roads are using and others are making experimental investigation of heat-treated carbon steel in locomotive frames, main and parallel rods and miscellaneous parts. Five roads are using heat-treated carbon steel springs, wheels and tires. Carbon heat-treated steel for piston rods, axles and crank pins is the more generally used of the treated steels, and ten roads in all are doing more or less work with this class of material.

C. D. YOUNG,

Chairman, Committee on Use of Special Alloy Steels and Heat-Treated Steel in Locomotive Construction.

The replies as to the use of alloy steels in locomotive construction are so varied that it can only be stated that alloy steels are being used to some extent, and the greatest quantity seems to be confined to locomotive frames, main and parallel rods, piston rods, axles and crank pins, although some roads are using alloy steels for springs. Vanadium is quite extensively used in frame material, eight roads making use of this element. For main rods, piston rods, axles and crank pins both vanadium and chrom-vanadium, with some nickel, are being used, and in spring material some silico-manganese, vanadium, chrom-vanadium and nickel have been employed. Some use has been made of vanadium and chrom-vanadium in cast iron, there being five roads making experiments with this material.

In the use of alloy steels in locomotive frames, five require heat treatment, whereas four do not, and for main and parallel rods, piston rods, axles and crank pins there seems to be about an equal number requiring heat treatment, as compared with those which do not require heat treatment of the material. For tires and springs the majority of the roads do not require special treatment, and for boiler steel, cast iron and miscellaneous parts no treatment is required by any one.

The following chemical requirements for various materials used with heat-treated carbon and alloy steels, seems to indicate tentatively the average existing practice:

PISTON RODS, AXLES AND CRANK PINS.

	Heat Treated Carbon Steel. Per cent.	Alloy Steel. Per cent.
Carbon	.45 to .60	.30 to .40
Manganese	.45 to .70	.40 to .65
Phosphorus, not over	.05	.05
Sulphur, not over	.05	.05
Silicon	.....	.15 to .30
Vanadium, not less than	.....	.16
Chrom	.....	.90 to 1.10

For the physical requirements the practice from the replies seems to indicate the following:

PISTON RODS, AXLES AND CRANK PINS.

	Elastic Limit Lbs. per Sq. In.	Ultimate Lbs. per Sq. In.	Elong. per cent. in 2 In.	Per cent. Reduc. of Area.
Heat Treated Carbon	50,000 Min.	85,000 Min.	22.0	45.0
Alloy	80,000 Min.	100,000 Min.	20.0	50.0

The Pennsylvania Railroad practice for heat-treated carbon steel for piston rods, axles and crank pins is approximate, depending upon the normal carbon of their specifications, namely, heating between 1,500 degs. and 1,600 degs. F. and quenching in water and drawing to a temperature of between 1,050 degs. and 1,150 degs. F., the material not being permitted to get entirely cold between quench and temper.

In a general way the use of heat-treated carbon and alloy steels has resulted in satisfactory service, increased mileage having been obtained from the materials with apparently fewer failures, although in the majority of the cases the material has not been in service long enough to make a fair reply.

Seven roads do not require any heat-treated carbon or alloy steel axles and crank pins to be drilled, whereas four roads are at this time requiring drilling for the proper treatment. Present tendency seems to be toward requiring the drilling of shafts of large diameters.

Most of the members have not found it desirable to use alloy steels and heat-treated carbon steels in designs where excessive vibration or shock is not expected, five roads stating that this is their present practice. One member is using this material for springs, one for side rods and one for all machinery parts for high-speed passenger locomotives.

Heat-treated carbon steel can be obtained at a slight advance in price, whereas alloy steels may be purchased at an increased cost, approximately double that of the plain carbon steel, heat-treated.

The report is signed by:—C D. Young (Penn.), Chairman; Henry Bartlett (B. & M.); S. M. Vauclain (Bald. Loco. Wks.); H. B. Hunt (Am. Loco. Co.), and J. C. Little (C. & N. W.).

C. D. Young presented the paper closing with the following remarks:

I would like to say with reference to the exhibits, that some of the manufacturers of alloyed steel have called our attention to apparent discrepancies in the replies which the Committee has received, in that all the information they have does not agree with the shipments made to various roads. The question of prices does not seem to be on the same basis, and I would suggest that in the publication of the Committee's report, we omit the appendices, and submit merely the report of progress, so there will be no confusion of facts from the data we received in reply to our circular. I suggest this after taking it up with the members of the committee.

DISCUSSION.

F. F. Gaines, (C. of Ga.): We have had two cases of heat treated axles in less than four to six weeks' service, where the axles broke off in a very peculiar manner, and it seems to me it must be due absolutely to the method of heat treatment, so much so that I would like to know if anyone else has had a similar experience. I have got to the point where I am rather afraid of them.

C. D. Young: I believe if heat treated material is purchased without careful inspection and test, that you are very apt to get even poorer material in the heat treated carbon steel than perhaps in annealed carbon steel, as the punching of a large mass of steel is very severe on the steel structure. If it is not properly and intelligently done, it may make the material poorer than it would be without that treatment, and it would be my suggestion to the members to buy this material on close testing and close observation of the treatment which is being given.

The Pennsylvania Railroad this year is installing a heat-trating plant, and it is our intention to not only subject the punching charges to a specimen test, but also to a drop test on each individual piece, in order to assure ourselves that we have given the proper treatment to the material. We expect to discontinue the drop test if we do not find any disastrous results. There has been quite a good deal of trouble, I understand, from improper heat treatment. Heat treatment will not make poor steel any better, it will make poor steel still worse, but it certainly will improve good steel.

J. F. DeVoy (C. M. & St. P.): The Milwaukee Road has tried to use these axles under about 200 locomotives. I am perfectly free in stating that under no circumstances whatever would I put a so-called heat-treated axle under a locomotive, with the methods as I know them. We have not tried a heat-treated axle, for there is no question in my mind whatever but that the heat treatment known now, will make a good steel about as bad as it can be. We planed the axles that failed down to the centre, and at about 4 in. from the surface on a 12 in. axle, cracks began to develop, and pieces broke off of their own weight. I do not just exactly understand what Mr. Young meant by making a proper inspection. A proper inspection of a heat-treated axle cannot be made for the reason that there is no way of testing them until you have reached a point at least 3 in. in from the outside of the axle.

SMOKE PREVENTION.

Several members of this committee were on a special committee appointed by the General Manager's Association of Chicago to determine the advantages of steam jets in locomotive fireboxes as an aid to smoke prevention, and it was on their recommendation that their report be transmitted to the committee for the use of this convention.

The chairman acknowledges his indebtedness particularly to the President of this Association for his careful test and its valuable deductions, and begs leave to submit it in full.

The report is signed by:—E. W. Pratt (C. & N. W.), chairman; J. F. DeVoy (C. M. & St. P.); W. C. Hayes (Erie); T. R. Cook (Penna.), and M. K. Barnum.

SMOKE PREVENTION BY USE OF STEAM JETS.

These smoke-abatement tests were made at the Altoona testing plant of the Pennsylvania to determine the merits and proper application of steam jet combustion tubes in a locomotive firebox for abating smoke, both with and without a brick arch, the special purpose being the development of a specification applicable to locomotives operating in the city of Chicago.

In brief, the results show that if from 4 to 6 lbs. of air per pound of coal fired is delivered over the fire by steam jet tubes, the emission of smoke will be reduced to a very low amount, and that while the brick arch is a benefit, particularly while the locomotive is running, the steam jet combustion tube is of value either with or without a brick arch.

E. W. PRATT,
Chairman, Committee on Smoke Prevention.

Locomotive No. 7042 (0-6-0) was selected for the tests as being representative of a large class of shifting engines in service in Chicago. The locomotive was equipped with a Security brick arch consisting of six rows of bricks supported on two 3-in. tubes with a 5-in. gap between the flue sheet and the front of the arch, as illustrated in Fig. 1.

The steam jet combustion tubes were applied in accordance with Fig. 1. There were eight tubes along each side of the firebox, six above the fire door on the back head, and four below the fire door. The tubes consisted of pieces of 2-in. boiler tubing, approximately 6 in. long, inserted in place of staybolts, and each tube was provided with a 3/16-in. steam nozzle connected to a ½-in. steam line. Arrangement was also made to use air in the nozzles in place of steam. The blower was of the double tip nozzle type and is shown in Fig. 2. Steam admission to the blower line was controlled by a quick-opening

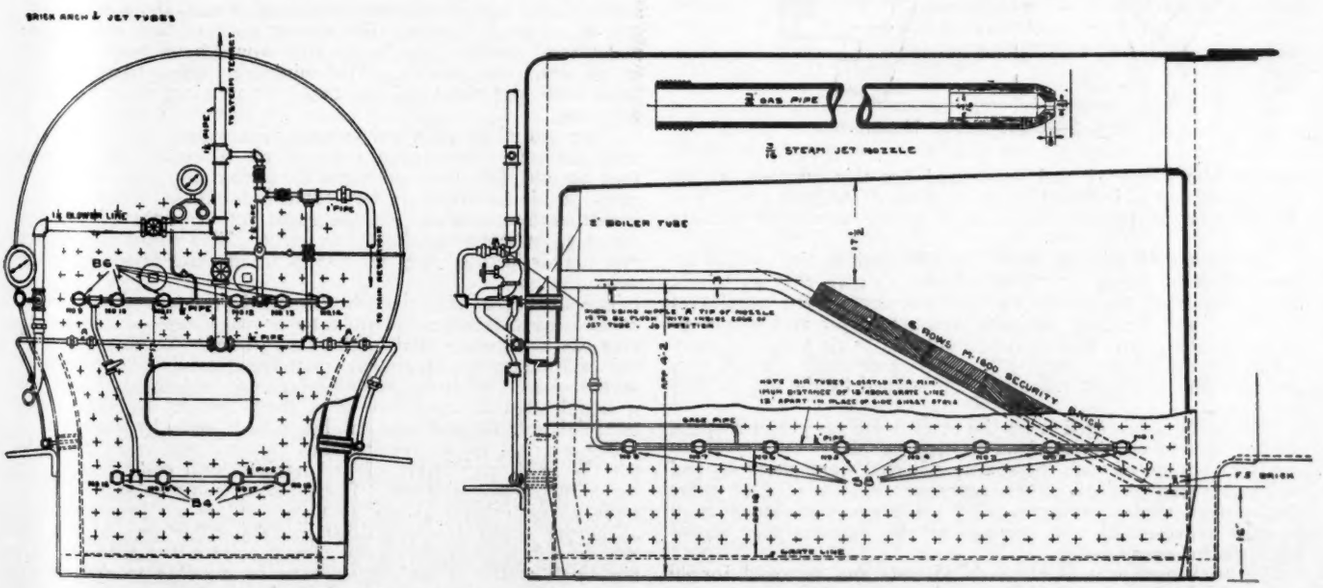


Fig. 1—Arrangement of Steam Jets in Firebox.

flat disk valve, which gave any desired pressure up to a maximum of 130 lbs.

The fire door was equipped with an adjustable damper and deflector. The damper was set with an effective opening of 10 sq. in., and the deflector at an angle of 30 degs. with the door, throughout the tests. The smoke box was of the self-cleaning type, with adjustable lift and deflector.

METHOD OF MAKING THE TESTS.

In order to obtain conditions similar to exacting yard service, the locomotive was run for seven minutes at a drawbar pull of about 15,000 lbs. at 12 m. p. h., and then shut off and allowed to stand for three minutes with the blower on full. The rated tractive effort of this locomotive is 26,517, so that 56 per cent. of the rated tractive effort was delivered, which made the locomotive work very hard. The minimum boiler pressure allowed was 170 lbs., or a variation of ten pounds from the rated pressure of 180 lbs.

While running, careful and uniform firing was insisted upon with a light, sloping fire, but as soon as the throttle was closed the fireman promptly threw a stated amount of coal under the front of the arch, to make plenty of smoke. One, four, none

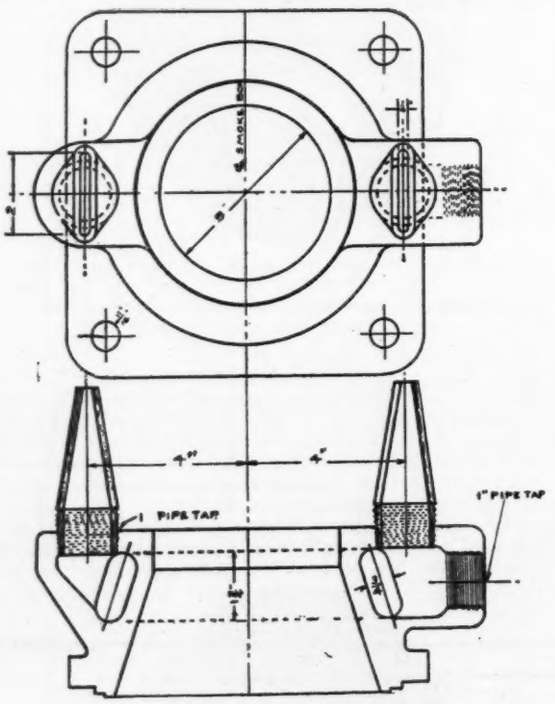


Fig. 2—Double Tip Nozzle.

and six shovelfuls of coal were used for this purpose on the four stops, and is included in the coal used for each test. The standing smoke may be considered as the result of careless firing.

The above cycle of tests was made with each of the various arrangements of steam jet tubes, selected to give data as to the best location of the tubes, the best location of the nozzles in the tubes, and the most desirable amount of air and steam injected by the tubes, with and without the brick arch.

The amount of air entering the firebox through the ash pan, fire door and steam-jet tubes was determined by the use of anemometers.

The sparks discharged from the stack were caught in a spark catcher erected on the roof on the testing plant.

After each set of tests the sparks collected were swept up and weighed. Analyses of eleven representative samples of these sparks were made. Analyses of the flue gas were made from samples representing the average of the running and standing tests for every cycle.

The brick arch was in place on 35 tests and removed for 40 tests. On 7 tests the gap between the arch and flue sheet was closed.

The coal used throughout the tests (except in nine efficiency tests) was furnished by the Superior Coal Company from the Benld Mine in Macoupin County, Illinois, and is representative of the coal used in the Chicago District. The following table gives the two analyses and the corresponding test numbers:

Number of tests	Fixed Carbon	Volatile Matter	Moisture	Ash	Sulphur Determined Separately
25	37.73	37.14	8.99	16.14	6.15
51	37.47	38.41	9.89	12.23	5.57

The noticeable features of this coal are the high ash, sulphur and moisture, which make it a very dirty, clinkering coal, of comparatively low heating value. The calorific values of the two carloads were 11,671 and 12,884 B. t. u. per pound dry coal, respectively.

After the best arrangement of steam-jet tubes, with and without the arch, had been determined, a series of efficiency tests was run at the same speed and cut-off, both with and without the arch, to determine the efficiency of the boiler and locomotive with the steam-jet tubes as compared with the same locomotive without tubes. These tests were run for one hour each.

To determine the merits of the steam-jet tube in abating smoke while a fire is being built in a locomotive, or while building up a fire after the firebox temperature has become very low, a series of firing-up tests was made, using the best arrangement of steam-jet tubes with the arch in place. Starting with a cold boiler, the fire was lighted and built up as rapidly as possible. Continuous smoke readings were made until boiler pressure was obtained.

RESULTS OF TESTS.

There is a great variation in the amount of smoke for a given quantity of air and steam and for a given condition, which no amount of care seems to overcome, and eliminating variable after variable does not appear to change this condition. The general law, however, is clearly defined, the smoke being reduced almost directly in proportion as the total quantity of air and steam above fire is increased until a practical limit of about 190 lbs. per minute is reached, above which it was impossible to go under the test conditions, on account of the locomotive failing to steam. At this point the curves indicate that little further reduction in smoke could be made with increased air and steam above the fire. They indicate that the locomotive would have made from 25 to 30 per cent. smoke under the test conditions with no air or steam admitted through the jets, although 4 tests gave only 13.5 per cent. with this condition, probably because the engine steamed freely enough for the fireman to keep the door open a good deal. The minimum smoke with normal brick arch was 6.5 per cent., or a reduction of about 75 per cent.

The ratio of air to steam seems to be immaterial, although some of the variations can be accounted for by the total pounds of air per pound of coal fired (including ash pan) being greater or less as the case may be, indicating that the quantity of air is the important factor. The jets in the back head above the fire door are apparently superior to the side jets.

In each case a further reduction of smoke was made by filling the gap between the arch and flue sheet.

In the standing tests it was possible to use the maximum amount of air and steam obtainable with the equipment, and accordingly the smoke was still further reduced, with the indication that a further increase of air and steam, above fire, would not be of great benefit. The curves indicate that with no air and steam admitted, the locomotive would have made from 25 to 30 per cent. smoke. The minimum smoke with normal brick arch was about 3.5 per cent., or a reduction of about 87 per cent.

The ratio of air to steam appears important in this case. The tests with no steam, or a ratio of air to steam greater than four to one, fall upon the same curve, but the tests where the ratio of air to steam is less than four to one resulted in a higher smoke reading for the same total weight of air and steam as indicated by the upper curve. This points to the fact that the air injected over the fire is the greatest factor in smoke reduction.

The amount of air injected, per pound of steam, should be increased as closely as possible to a maximum of 25 lbs., to give the best results and at the same time make an economical use of the steam. This means that the quantity of air injected by the steam jets is the valuable factor in smoke reduction, but it is felt that the presence of a small amount of moisture is essential, and therefore the air should be injected by steam jets.

The average smoke results when running, and with and without the brick arch, were plotted against total cubic feet of air per minute above the fire. These curves show substantially the same characteristics as the total air and steam curves, except a sharper break at from 2,000 to 2,400 cubic feet of air per minute, which seems to be the critical point either with or without brick arch. It also appears to be possible to reduce the smoke when standing without the arch to as low a figure as with the arch, when using the jets in the back head above the fire door, although the side jets lose considerable ground without the arch.

The intensity of draft in the front end being the same on all tests except for the variation in steam pressure, the amount or air drawn through the grates is reduced by the amount injected over the fire by the steam jets, the total being constant. This means that the steam jets reduce the firebox vacuum and explains the greatly reduced coal consumption on tests where a large amount of air was injected.

Curves indicate that the greater the total amount of air per pound of coal the less smoke, and that the back head jets are superior to the side jets, although both are capable of reducing smoke to about 6.5 per cent., under the test conditions, when the total air per pound of coal is greater than 13 lbs. and 35 per cent. of it is injected above the fire.

Assuming the locomotive would have averaged 20 per cent. smoke when running without the jet tubes, curves show that when about 4 lbs. of air per pound of coal fired is injected over the fire, this smoke may be reduced to 7.5 per cent., or a reduction of about 62 per cent.

The average smoke when standing may be reduced from, say, 30 per cent. to 4 per cent., or a reduction of about 87 per cent., when 4.5 pounds of air per pound of coal is injected by the back head jets or 5.5 pounds of air by the side jets.

The back head jets reduced the smoke when standing even lower without the arch than with it, although they were not able to do so while running. The side jets show a loss of efficiency both when running and standing.

The brick arch greatly improves the performance of the side jets, which might be expected, since the arch helps the admixture of air and combustible gases and creates a longer flameway, thus making the longest possible passage for the air injected at the sides. The jet tubes on opposite sides were directly opposite each other, so that the columns of air and steam met in the center of the firebox. The back head jets, however, seem to be as good without the arch as with it, and therefore considerably superior to the side jets without the arch.

In general, when the average smoke is reduced, the maximum smoke is also reduced, and that when the average smoke is reduced to 7 per cent. the maximum density of the smoke emitted at any time will not be higher than No. 1 on the Ringelmann scale.

In order to determine if possible whether it was the distance from the flue sheet or the height above the fire that was important, tests were run with the five side jets on either side farthest from the flue sheet in use. The resulting smoke was very high in all cases, indicated that the height above the fire had is the most important feature with the upper back head jets. Referring to Fig. 1, showing the relative position of the jet tubes and brick arch, it is seen that the upper back head jet tubes are practically on a line with the back edge of the arch, and it is highly probable that a large part of the air injected by these jets was drawn over the top of the arch directly into the flues by the draft of the locomotive and never reached the fire at all. This would also account for the fact that these jets with the brick arch gave no better smoke results than without the arch, if as good.

EFFICIENCY TESTS.

Penn Gas coal was used for the efficiency tests, with the exception of 2 tests in order to make the locomotive steam. While Penn Gas coal is a high volatile, smoky coal, the analysis shows practically the same volatile matter as the Illinois coal used in the other tests, with a considerably higher heating value, and it was possible to reduce the smoke to quite as low a figure, so that the results are fairly comparable. One point of interest is that with no jets in use, the same smoke was obtained with and without the brick arch. This was probably due to the fact than on one test without the arch, the fireman was able to keep the door open a good deal after putting in a fire, and again it may be due to the unaccountable variations in smoke.

The curves drawn from the results indicate that, while running, the brick arch is capable of making a 50 per cent. reduction in smoke, irrespective of the steam jets. The upper back head jet tubes are capable of reducing the smoke approximately 60 per cent. without the arch and 70 per cent. with the arch, with approximately 5.5 lbs. of air per pound of dry coal. The two tests made with the side jets did not show that they had very much merit.

ECONOMY OF THE STEAM-JET TUBES.

The results of the efficiency tests show that a reduction of smoke results in an increase in equivalent evaporation and a corresponding increase in efficiency and economy with or without the brick arch, showing that the steam-jet tubes make for improved combustion and economy, rather than simply "whitewash" the smoke. The brick arch itself shows an average increase in evaporation of about 8.6 per cent.

As the smoke is reduced the rate of combustion is reduced either with or without the arch. Since the drawbar horse-power of the locomotive was practically the same on all tests, this seems to be direct economy. But the firebox vacuum is reduced by the air thrown over the fire to reduce smoke and therefore it was impossible to burn as much coal. To be sure, the locomotive steamed and the drawbar horse-power was maintained, but on many of the tests it was necessary to fill the boiler before starting and keep the injector off until the stop, in order to maintain steam pressure within the limit of 170 lbs. This could not, of course, be done with a road locomotive, but it is entirely possible with the majority of shifting locomotives, and although the economy shown is not direct, a proportion of it is, because on the efficiency tests the water level in the boiler was maintained at all times, and there was a resulting economy from the use of the steam-jet tubes. In yard service it is probably that a much larger economy could be effected by using the jet tubes to check combustion.

Taking account of the variations in drawbar horse-power, it was also shown that below about 10 per cent. smoke the increase in economy is not so great.

SPARKS.

The average analysis of the sparks discharged on 44 tests (11 cycles), with and without arch, is as follows:

Volatile Matter	Fixed Carbon	Ash	Sulphur Determined Separately	British Terminal Units
12.36 per cent	46.76 per cent	40.88 per cent	2.98 per cent	7810

The average heating value of the Illinois Coal was 12,227 B. t. u. per pound dry coal, hence the sparks had 63.7 per cent. of the heating value of the coal. This may explain the increased economy when using the steam jets, coupled as it is with the reduction of smoke. Allowing for the reduction in smoke by the brick arch, it is seen that the arch does not reduce the amount of sparks discharged, and the indications are that more sparks are discharged with the arch than without it.

FIREBOX TEMPERATURE.

The firebox temperature was uniformly high, no definite relations between it and the amount of air above the fire being apparent, although it is fair to presume that a large amount of air above the fire would reduce the firebox temperature enough to offset the increase due to better combustion. The average temperature of the firebox without the arch was 1,697 degs. F., and with the arch 1,911 degs. F., or an increase of 12.6 per cent.

On the efficiency tests with Penn Gas coal, the average firebox temperature was 1,888 degs. F. without the arch and 2,166 degs. with the arch, or an increase of 15.8 per cent.

BLOWERS.

The operating pressure of the blower was maintained as nearly uniform as possible to make the draft the same for all tests. The maximum pressure obtainable on the blower with full boiler pressure was 130 lbs., and this gave a front-end vacuum nearly equal to that of the 5-in. nozzle under running conditions.

To determine the value and economy of the blower used (see Fig. 2), it was compared with a double-tip stack blower as it was temporarily applied for this test. The tips were arranged so that the tube jets would meet about half way up the center of the stack, and they had precisely the same area of opening as the double-tip blower used in the smoke test. A multiple-tip blower was also compared. All three blowers had the same blower valve and line from the steam turret.

Comparing the blowers according to vacuum and steam consumption, the multiple blower is the most efficient of the three, with the double-tip blower, applied at the nozzle, the next. The objection to the multiple-tip blower is the liability of the tips to become clogged up or broken off.

FIRING-UP TESTS.

Three firing-up tests were made with a cold boiler to determine the efficiency of the steam jets with a low firebox temperature. The following table gives results.

Test No.	Jet Tubes in Use	Time to Obtain Full Boiler Pressure. Minutes.	Cubic Feet of Air per Minute From Jets.	Maximum Smoke No.	Average Smoke in Per Cent.	Corresponding Smoke in Per Cent.
1		68		4	28	25
2	Upper back head	68	1,670	2	20	8
3*	Upper back head	74	1,525	2	16	10

*Double Tip Stack Blower.

The double-tip nozzle blower was used on the first two tests, and the blower was the same on all three. The results show that the steam jets are capable of reducing smoke even when the

firebox temperature is low, but they are not as efficient as when it is high, as might be expected. Hence they would be of service at all times in shifting service, but in greater degree when the firebox temperature is high.

SIZE AND POSITION OF STEAM-JET NOZZLES.

From the results outlined in the previous paragraphs, two things are apparent: First, that a large quantity of air must be injected over the fire by the steam-jet tubes to reduce smoke properly, and, second, that this air should be injected with the least amount of steam practicable. To determine the proper arrangement of the steam-jet tubes to fulfill these requirements, complete air and steam calibrations were made upon ⅛-in., 3/16-in. and ¼-in. nominal diameter steam nozzles in the 2-in. outside diameter jet tube.

It was found possible to move the nozzle from the inner end of the tube to a position 8½ in. from the inside edge, or approximately 2½ in. beyond the outer end of the tube, and in case of the ¼-in. nozzle 3½ in. beyond the outer end, with a continually increasing quantity of air injected into the firebox. Beyond that position the quantity of air falls off, probably due to the greater friction of the steam in the tube and the striking of the outer edge of the jet of steam on the firebox sides. The indications are that the most efficient position is where the jet of steam expands and completely fills the tube just before reaching the inner end of the tube.

The ⅛-in. nozzle is the most efficient of the three, with the 3/16-in. slightly less efficient and the ¼-in. very much less efficient. All three are more efficient as the operating pressure decreases. While the ⅛-in. nozzle is most efficient, the 3/16-in. nozzle is capable of injecting 50 per cent. more air with only slightly less efficiency, and, in general, would probably be the desirable nozzle to use.

CONCLUSIONS.

The steam-jet combustion tube has a decided value in reducing smoke under the widely varied conditions of these tests. The air injected by the tube was found to be the greatest factor in reducing smoke, although a small amount of steam seems essential in smoke reduction. When using steam-jets, injecting air into the firebox, it was apparent that a greater reduction in smoke was accomplished by their use with improper firing as compared with careful firing. The firebox temperature was found to be higher when the arch was in service as compared with the plain firebox, although the data do not consistently show that a reduction in smoke follows increased firebox temperature.

The steam-jet tubes seem to give the best results in preventing smoke when located so that the injected air and steam meet the flame as high as possible above the fuel bed. If the arch is used the best results seem to be obtained when the air passes underneath the arch as high as possible above the fuel bed. The arch gives better results in smoke prevention if it fits tight against the flue sheet. A tight arch, however, has the practical disadvantage of collecting deposits of sparks and eventually closing the lower flues.

An efficient design of smoke-box blower is an important factor in smoke abatement. Air openings in the fire door are of slight assistance in smoke abatement, as they are capable of supplying only about 10 per cent. of the air necessary above the fire and a very small percentage of the total air for complete combustion.

Best results were obtained when from 4 to 6 lbs. of air per pound of coal fired was injected by the steam tubes from a location in the back head above the fire door. It was found on these tests that the total amount of air, including that which was introduced above the fire, should not be less than 13 lbs. per pound of coal for good smoke prevention.

The data seem to indicate that the best results can be obtained when the least amount of steam is injected with the greatest amount of air.

The use of the steam-jet tubes results in considerable economy, and in the efficiency tests an increase in evaporation was obtained.

The steam-jet tubes apparently reduce the weight of sparks discharged from the stack, but the data were not of a character to firmly establish this point.

There is a necessity for a quick-acting, easily operated valve capable of giving reasonable graduations in pressure.

It was found during the tests that the steam nozzles were being worn by the steam and this accounts for the inability of the steam lines to supply as great a pressure to the jets as desired in some of the later tests. The nozzles were made of brass. The indications are that they should be made of steel and, if necessary, hardened. The 3/16-in. diameter steam nozzle seems to be the desirable one to use in a 2-in. tube.

There is noise incident to the use of the steam-jet tubes in the most efficient arrangement, and if the steam-jet tubes are located in the cab they should be covered with a ⅜-in. cast-iron box provided with cast-iron air intake from a point outside the cab, the air intake being provided with a muffler.

DISCUSSION.

W. H. Fetner (Cent. of Ga.): I notice in the conclusion that the committee states that the best results were obtained when the arch hit against the flue sheet. I have had the same experience, and like your committee have had the experience of being unable to keep the lower flues clean on account of accumulation of sparks. The road with which I am connected, however, has a plan which gives us the benefit of this tight arch without the difficulty of keeping the flues clean, and taking care of the sparks. It is done by the application of a spark-hopper, which enables us to take care of the sparks and get results which we did get from the tight arch. The hopper is located on a casting that is used to support the arch. The arch is similar to the arch used in stationary practice very much now.

T. H. Curtis (communication read by Mr. Taylor): While the human factor, the fireman, is the greatest regulator of smoke-emission, the fact must not be lost sight of that this fireman will produce the best results on locomotives equipped with adequate and efficient appliances.

I suggest that paragraph 65, page 38 (first paragraph under "Sparks" in Abstract) be revised, as its present content is liable to give an erroneous impression. From this paragraph I quote:

"Allowing for the reduction in smoke by the brick arch, it is seen that the arch does not reduce the amount of sparks discharged, and the indications are that more sparks are discharged with the arch than without it."

The following burning rates are cited, as the production of sparks is dependent, to an appreciable degree, upon the burning rate per square foot of grate surface per hour and the kind of coal burned. In the thirty-two tests made with the brick arch the maximum rate of coal burned per square foot of grate surface per hour was 87.3 lbs.; minimum 60.1 lbs., average 72.4 lbs. With no arch, for nine tests, the maximum was 75.7 pounds; minimum 63.5 pounds; average 70.1 pounds.

We are fortunate to have data, other than that given in this report, that is of great importance in considerisg the efficiency of the brick arch relative to the abatement of sparks. The tests of Macoupin County, Ill., coal conducted for the General Managers' Association of Chicago showed more sparks produced with the arch than without it, the burning rates for these tests ranging from a minimum of 60.1 to a maximum of 87.3 lbs. of coal per square foot of grate surface per hour. The Chicago Association of Commerce Committee of Investigation on Smoke Abatement and Electrification of Railway Terminals had tests conducted at Altoona, Pa., with ten representative bituminous coals from Illinois, and Indiana. Four of these coals were tested with and without the arch, at a rate of burning of from 30 to 100 lbs. per sq. ft. of grate surface per hour. (Two of these coals were from different counties in Indiana, and the two from different counties in Illinois—Macoupin County being one of them). The averages for these four coals were: At the minimum burning rate of 30 lbs. of coal per sq. ft. of grate surface per hour, the tests showed 40.7 per cent. more sparks with the arch than without it; at the burning rate of 40 lbs. of coal, the tests showed only 7.4 per cent. more sparks with the arch than without it; at the burning rate of 50 lbs. of coal, the tests showed 10 per cent. less sparks with the arch than without it; at the burning rate of 60 lbs. of coal, the tests showed 16.7 per cent. less sparks with the arch than without it; and at the burning rate of 100 lbs. of coal, the tests showed 41.5 per cent. less sparks with the arch than without it. The benefit of the brick arch in the abatement of sparks commences with the burning rate of about 45 lbs. of coal per sq. ft. of grate surface per hour, and increases with the burning rate as shown by the average results from the four coals tested with and without the brick arch.

The finding as to the comparative percentages of sparks emitted with and without the brick arch, in the tests of the four coals, discloses that the results from the brick arch are the opposite of that reported in this report to the American Railway Master Mechanics' Association for burning rates of about 45 lbs. and over.

From the previously mentioned paragraph I further quote:

"The average heating value of the Macoupin coal was 12,277 B. t. u. per lb. of dry coal, hence the sparks had 63.7 per cent. of the heating value of the coal."

I beg to suggest that changes and additions be made to this paragraph so as to read: "65. The average analysis of the sparks discharged on 44 tests (11 cycles), with and without arch, is as follows:

Volatile Matter	Fixed Carbon	Ash	Sulphur Determined Separately	British Thermal Units
12.36 per cent.	46.76 per cent.	40.88 per cent.	2.98 per cent.	7,810

"The average heating value of the Macoupin coal was 12,277 B. t. u. per lb. of dry coal, and the average heating value of the sparks emitted when burning this coal was 7,810 B. t. u. per lb. of dry sparks and therefore, for equal weights of dry coal and dry sparks, the sparks had 63.7 per cent. of the heating value of

the coal. With the weight of sparks ranging from 2 per cent. to 8 per cent. of the weight of the coal, and the B. t. u. of the sparks averaging 63.7 per cent. of the B. t. u. of the coal, the spark loss would range from 1.3 per cent. to 5 per cent. of the heat in the coal. This may explain the increased economy when using the steam-jets, coupled as it is with the reduction of smoke. Allowing for the reduction in smoke by the brick arch it will be seen that the arch does not reduce the amount of sparks discharge, and the indications are that more sparks are discharged with the arch than without it, when burning Macoupin County coal. (The tests with four coals from Indiana and Illinois which were made at Altoona, showed results as to the production of sparks which were in accord with this report, for burning rates under 45 lbs. of coal, and opposite for burning rates of 45 lbs. of coal and over.) From the results of the tests with and without the brick arch in the firebox, it is apparent that the kind of bituminous coal and the rate of burning are important factors in determining the merits or demerits of the brick arch as an appliance for the abatement of sparks."

I would suggest that in the entire report the words "spark" and "sparks" be changed to "cinder" and "cinders" respectively, as the American Railway Master Mechanics' Association's locomotive dictionary gives preference to the word "cinder;" further, Webster defines "spark" as a small particle of fire or ignited substance emitted by a body in combustion, and I do not think the impression should be given that the particles emitted from the stack are ignited.

E. W. Pratt: Several Chicago Railroads have equipped a large number of locomotives in accordance with the recommendation of this report, and found in practice that the suggestions are eminently practical. I would like to call to your attention the following paragraph under recommendations:—"Jet Tubes of a minimum outside diameter of 2 in. should be used and located on the back head or side sheets of the firebox, dependent upon the most efficient location for the specific dimensions and type of firebox under consideration." I read to you recommending them on the back head. The side sheet is recommended by several roads and the results obtained were satisfactory.

In regard to the comments of Mr. Curtis, I want to say that in conducting these tests, it was only natural that all data obtained, whether directly referring to the smoke-tests or not, should be jotted down. That is to say, a particular type of locomotive, particular style of grate area, working at certain intervals and standing at certain intervals. In paragraph 64, on page 38, it says "The percentage of total coal fired which was discharged as sparks is plotted against total pounds of air and steam per minute above the fire and smoke in per cent. when running in Figs. 24 and 25. The curves show that the steam-jet tubes have the same effect on the quantity of sparks discharged as they do upon smoke, and therefore the two are proportional to each other." That was true in this particular test and Mr. Curtis was fearful that some member might read that alone, and read the conclusion in paragraph 103, which calls particular attention to the fact that while the steam-jet tubes apparently reduce the weight of the sparks, the data was not of a character to establish this point.

In paragraph 65, page 38 (second paragraph under sparks in above abstract) speaking of the analysis of the sparks, it states: "The average heating value of the Macoupin coal was 12,277 B. T. U. per pound dry coal; hence the sparks had 63.7 per cent. of the heating value of the coal." That, of course, meant pound for pound—a pound of sparks contained two-thirds of the total heat of a pound of coal.

ENGINE AND TENDER WHEELS.

The committee has made a careful study of the design of solid carbon wheels for engine truck and tender service, as made by the various steel wheel manufacturers, and used by the members of this association.

In reference to the question of working up specifications and designs for chilled cast-iron wheels for 140,000-pound capacity tenders, no action has been taken, as the question of increased thickness of flange and its relation to frog and guard-rail clearance has not been determined upon, and until such time the committee does not feel warranted in recommending a design for this capacity chilled cast-iron wheels.

Recommendation No. 1.

Specification for solid wrought carbon steel wheels for locomotive and tender service:

I.—Manufacture.

Process.—The steel shall be made by the open-hearth process.

Discard.—A sufficient discard shall be made from the top of each ingot from which the blanks are made to insure freedom from injurious piping and undue segregation.

II.—Chemical Properties and Tests.

Chemical Composition.—The steel shall conform to the following requirements as to chemical composition:

	Acid.	Basic.
Carbon	0.60-0.80	0.65-.85 per cent.
Manganese	0.55-0.80	0.55-0 80 per cent.
Silicon	0.15-0.35	0.10-0.30 per cent.
Phosphorus	Not over 0.05	Not over 0.05 per cent.
Sulphur	Not over 0.05	Not over 0.05 per cent.

Ladle Analyses.—To determine whether the material conforms to the requirements specified in Section 11, an analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt. A copy of this analysis shall be given to the purchaser or his representative.

Check Analyses.—A check analysis may be made by the purchaser from any one or more wheels representing each melt and this analysis shall conform to the requirements specified. A sample may be taken from any one point in the plate or

W. GARSTANG,
Chairman, Committee on Engine Tender Wheels.

two samples may be taken, in which case they shall be on radii at right angles to each other. Samples shall not be taken in such a way as to impair the usefulness of the wheel. Drillings for analysis shall be taken by boring entirely through the sample parallel to the axis of the wheel; they shall be clean from scale, oil and other foreign substances. All drillings from any one wheel shall be thoroughly mixed together.

Limits of Segregation.—The segregation of either element of carbon, manganese and phosphorus must not exceed 6 per

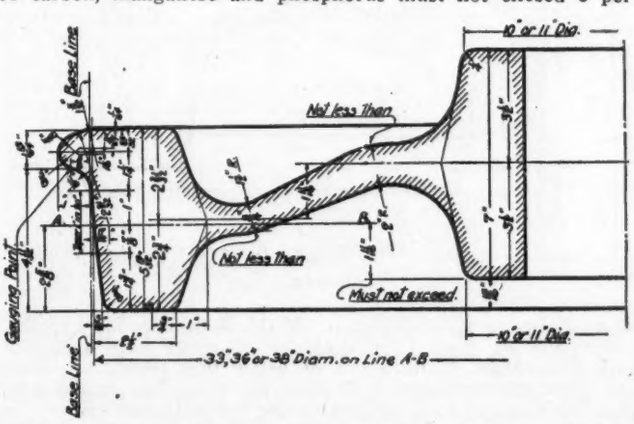


Exhibit A—33 in., 36 in. or 38 in. Solid Steel Tender Wheels for 4 1-4 in. x 8 in., 5 in. x 9 in. and 5 1-2 in. x 10 in. Axles.

cent. of the ladle test of the same melt or any part forming the thickness of the plate and tread and rim of the wheel.

III.—Tolerances.

Wheels should be furnished rough bored and with faced hubs and have a contour of tread and flange as rolled or machined according to M. M. Recommended Practice, Sheet 1, Fig. 1. They shall conform to dimensions specified on

drawings shown on Exhibits A, B and C herewith, within the following tolerances:

Height of Flange.—The height of flanges should not be more than 1/16 in. over and must not be under that specified, or 1 in.

Thickness of Flange.—The thickness of flange shall not vary more than 1/16 in. over or under that specified.

Throat Radius.—The radius of the throat shall not vary more than 1/16 in. over or under that specified.

Thickness of Rim.—The thickness of rim to be measured between the limit-of-wear groove and the top of the tread at the point where it joins the fillet at throat of flange. The average thickness of service metal of all wheels in any shipment must not be less than 1¾ in., measured from the limit-of-wear-groove to top of tread. The thickness of rim should in no case be less than 3/16 in. under that specified.

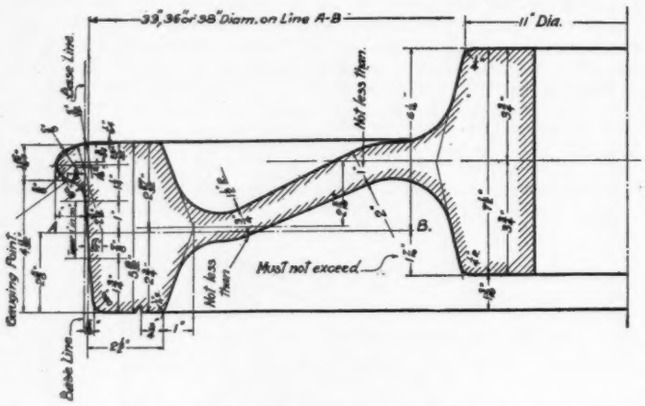


Exhibit B—33 in., 36 in. or 38 in. Solid Steel Wheels for 6 in. x 11 in. Axles.

Width of Rim.—The width of rim shall not be more than 1/8 in. less, nor more than 1/8 in. over that specified.

Thickness of Plate.—The thickness of the plate of the wheel shall not be less than ¾ in. at the point where the plate joins the fillet at the rim and not less than 1 in. at the point where the plate joins the fillet at the hub. Intermediate minimum thickness to be proportional.

Limit-of-wear Groove.—The limit-of-wear groove to be located as shown on wheel drawings. M. M. Recommended Practice.

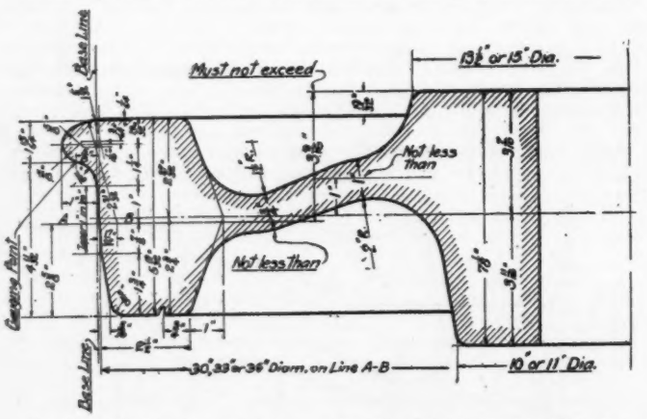


Exhibit C—30 in., 33 in. and 36 in. Steel Engine Truck Wheels.

Diameter of Bore.—The diameter of rough bore shall not vary more than 1/16 in. above or below that specified. When not specified, the rough bore shall be ¼ in. less in diameter than the finished bore, subject to the above limitations.

Hub Diameter.—The hub may be either 10 in. or 11 in. in diameter, as specified for tender wheels and outside hub of engine wheels, and 13½ in. and 15 in. in diameter for inside hubs on engine truck wheels. Maximum variation of 1/8 in. below. The thickness of the wall of the finished bored hub shall not vary more than 3/8 in. at any two points on the same wheel.

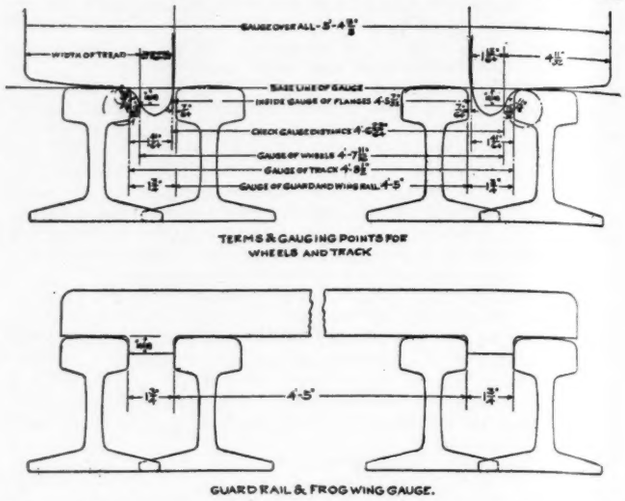

Gauge over all - 5'-4⅜"
Width of Tread
Base Line of Gauge
Inside Gauge of Flanges 4'-5⅜"
Check Gauge Distance 4'-6⅜"
Gauge of Wheels 4'-7⅛"
Gauge of Track 4'-8½"
Gauge of Guard and Wing Rail 4'-5"
TERMS & GAUGING POINTS FOR WHEELS AND TRACK
4'-5"
GUARD RAIL & FROG WING GAUGE.

Exhibit Z—Terms and Gaging Points for Wheels and Track.

Hub Length.—The length of the hub shall not vary more than 1/8 in. over or under that specified.

Depression of Hub.—The depression of the hub must be made so that the distance from the outside face of the hub to the line "AB" shall not exceed 1 11/16 in. for tender wheels on 5½-in. axles and under, and 1 7/16 in. for tender wheels on 6 by 11 in. axles. For engine truck wheels the distance from the inside face of the hub to the line "AB" shall not exceed 3/16 in.

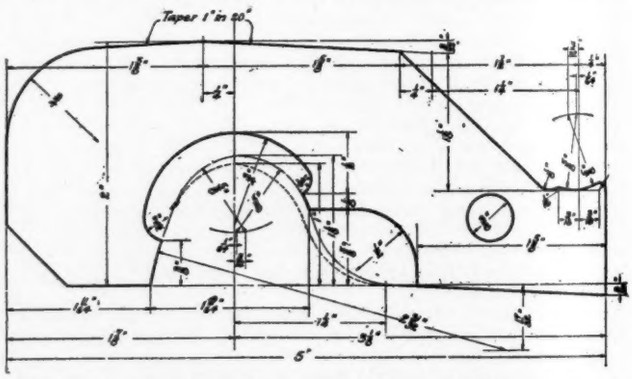


Exhibit W—Maximum Flange Thickness, Height and Throat Radius Gage.

Black Spots in Hub.—Black spots will be allowed within 2 in. of the face of the hub, but must not be of such depth that they will not bore out and give clear metal at finished size of bore.

Eccentricity of Bore.—The eccentricity between the tread at its center line and the rough bore shall not exceed 3/64 in.

Block Marks on Tread.—The maximum height of block marks must not be greater than 1/64 in.

Rotundity.—All wheels shall be gaged with a ring gage and the opening between the gage and tread at any one point shall not exceed 1/16 in.

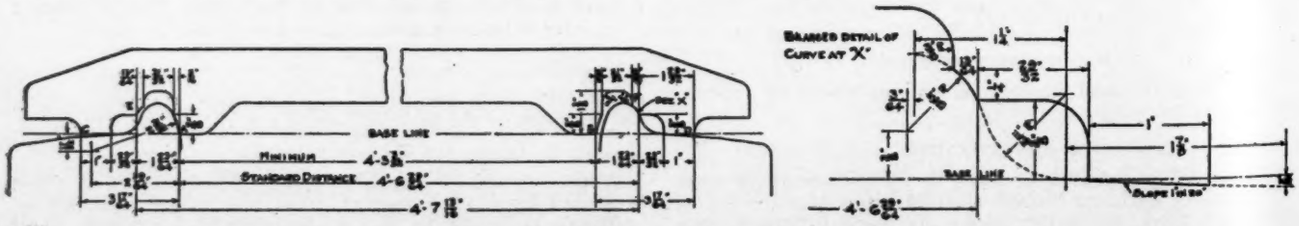


Exhibit X—Wheel Mounting and Check Gage.

Plane.—Wheel shall be gaged with a ring gage placed concentric and perpendicular to the axis of the wheel. All points on the back of the rim equidistant from the center shall be within a variation of 1/16 in. from the plane of the gage when so placed.

Tape Sizes.—Wheels shall not vary more than five tapes under nor nine tapes over the size called for.

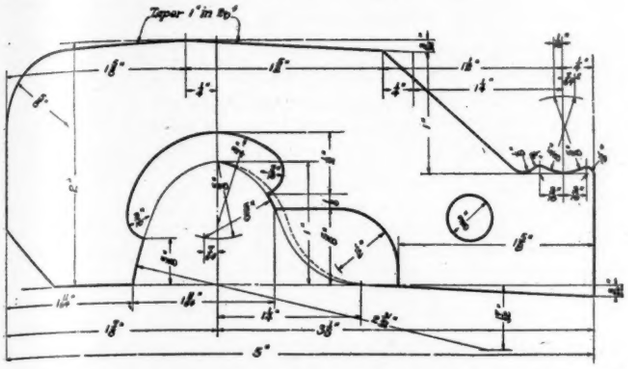


Exhibit V—Minimum Flange Thickness, Height and Throat Radius Gage.

Mating.—The tape size shall be marked in plain figures on each wheel. Wheels must be mated to tape sizes and shipped in pairs.

Gage.—Gages and tape used shall be M. M. Recommended Practice.

IV.—BRANDING.

The name or brand of the manufacturer, date and serial number shall be legibly stamped on each wheel in such a way that the wheel may be readily identified. The tape size shall be legibly marked on each wheel.

V.—FINISH.

The wheel shall be free from injurious defects, and shall have a workmanlike finish.

Wheels shall not be offered for inspection if covered with paint, rust, or any other substance to such an extent as to hide defects.

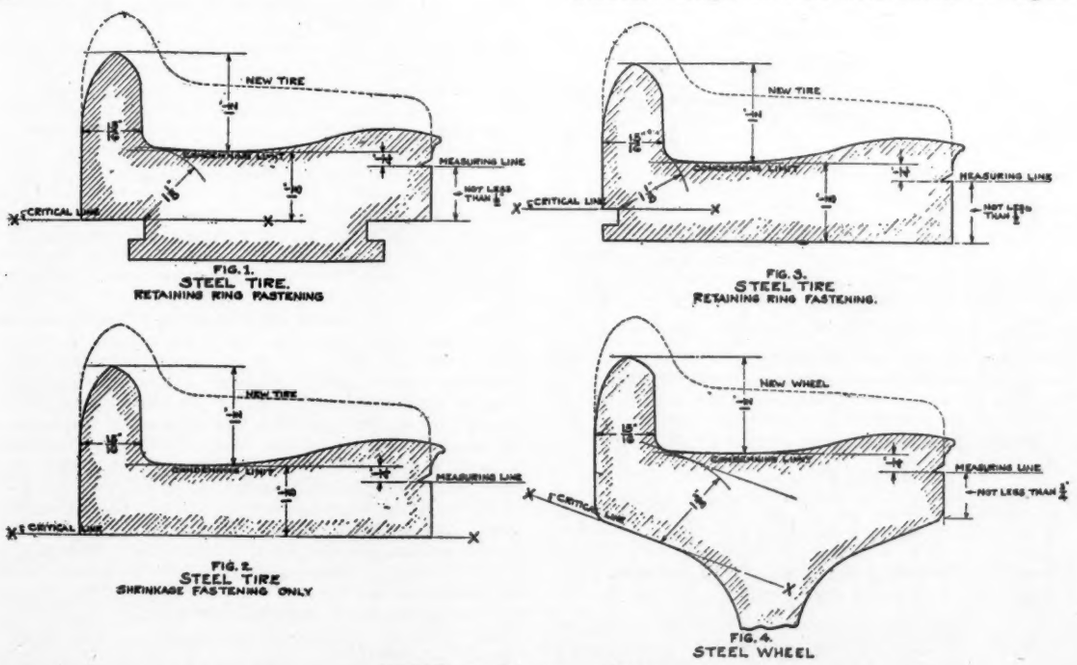


FIG. 1. STEEL TIRE. RETAINING RING FASTENING

FIG. 3. STEEL TIRE. RETAINING RING FASTENING.

FIG. 2. STEEL TIRE SHRINKAGE FASTENING ONLY

FIG. 4. STEEL WHEEL

Exhibit S—Limits of Wear.

VI.—INSPECTION.

Inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered.

The manufacturer shall afford the inspector, free of cost, all reasonable facilities and necessary gages to satisfy him that the wheels are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment, and free of cost to the purchaser.

The purchaser may make the tests to govern the acceptance or rejection of material in his own laboratory or elsewhere as may be decided by the purchaser. Such tests, however, shall be made at the expense of the purchaser.

All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Wheels that show injurious defects while being finished by the purchaser shall be rejected, and manufacturer properly notified.

Samples of rejected material must be preserved at the laboratory of the purchaser for one month from date of test report.

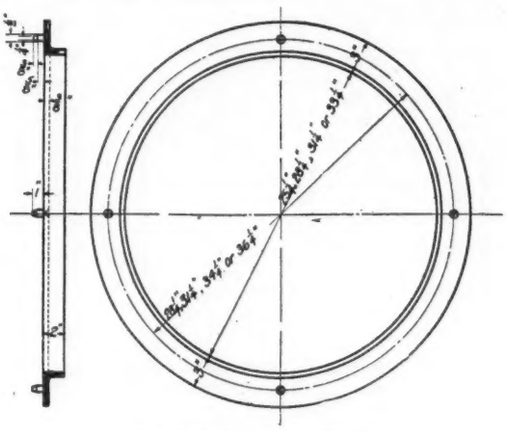


Exhibit R—Plane Gage.

In case of dissatisfaction with the results of the test, manufacturer may make claim for a re-hearing in that time.

It is recommended that the following gages and cuts be adopted as standard and shown in the Proceedings of the association, as follows:

RECOMMENDATION NO. 2.

Standard design for solid steel wheels for engine and tender truck service to be as shown on the following drawings:

33-in., 36-in. and 38-in. solid steel wheel for tenders, 5½ in. axle or under, Exhibit A.

33-in., 36-in. and 38-in. solid steel wheel for tenders, 6 by 11 in. axle, Exhibit B.

30-in., 33-in. and 36-in. solid steel wheel for engine trucks, Exhibit C.

RECOMMENDATION NO. 3.

Terms and gaging points for wheels and track as shown on drawing, Exhibit Z.

RECOMMENDATION NO. 4.

Guard-rail and frog-wing gage shown on drawing, Exhibit Z.

RECOMMENDATION NO. 5.

Wheel-mounting and check gage as shown on drawing, Exhibit X.

RECOMMENDATION NO. 6.

Maximum flange-thickness, height and throat-radius gage for

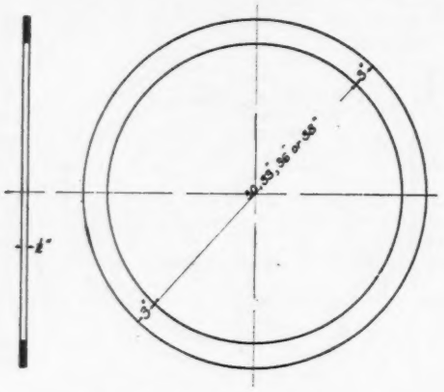


Exhibit Q—Rotundity Gage.

solid steel, steel-tired and chilled cast-iron wheels, as shown on drawing, Exhibit W, to be substituted for maximum flange-thickness gage shown on M. M. Sheet No. 14.

RECOMMENDATION NO. 7.

Minimum flange-thickness, height and throat-radius gage for solid steel, steel-tired and chilled cast-iron wheels shown on drawing, Exhibit V, to be substituted for minimum flange-thickness gage shown on M. M. Sheet No. 14.

RECOMMENDATION NO. 8.

Standard wheel-circumference measure for cast-iron wheels

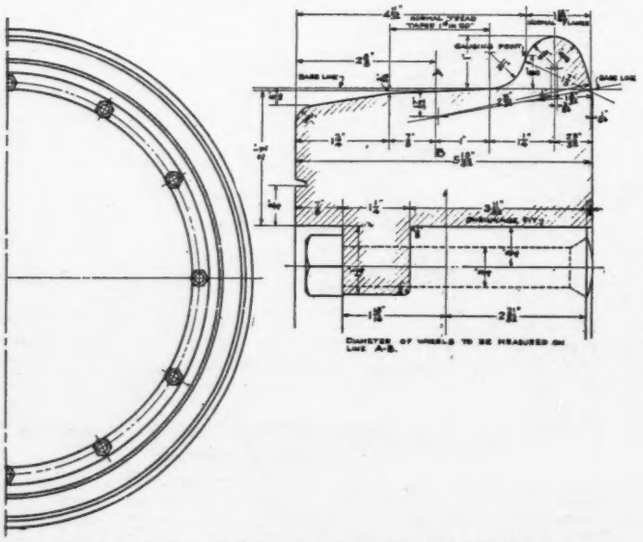


Exhibit L—Tire Fastening for Steel Tired Wheels.

as shown on M. M. Sheet No. 14, to be changed as shown on drawing, Exhibit U. [Not reproduced.—Editor.]

RECOMMENDATION NO. 9.

Standard wheel-circumference measure for steel and steel-tired wheels as shown on drawing, Exhibit T. [Not reproduced. —Editor.]

RECOMMENDATION NO. 10.

Cuts giving minimum thickness or limit of wear for steel tires with retaining-ring fastenings, shrinkage fastening only, retaining-ring fastening, solid steel wheels, to be shown as per drawing, Exhibit S.

RECOMMENDATION NO. 11.

Plane gage for 30-in., 33-in., 36-in. and 38-in. solid steel engine and tender truck wheels as shown on drawing, Exhibit R.

RECOMMENDATION NO. 12.

Rotundity gage for 30-in., 33-in., 36-in. and 38-in. solid steel engine and tender truck wheels as shown on drawing, Exhibit Q.

RECOMMENDATION NO. 13.

Gage for measuring steel wheels to restore contour as shown on drawing, Exhibit P. [Not reproduced.—Editor.]

RECOMMENDATION NO. 14.

Limit gage for remounting cast-iron wheels and method of using same as M. C. B. Standard Practice, Sheet 16-A.

RECOMMENDATION NO. 15.

According to specifications for solid steel wheels, Recommendation No. 1, the method of branding solid steel wheels and size of letters for branding to be as shown on drawing, Exhibits N and N-1. [Not reproduced.—Editor.]

RECOMMENDATION NO. 16.

It is recommended that the M. C. B. revised and rearranged specification for chilled cast-iron wheels be substituted for the specifications of chilled cast-iron wheels for tender service, shown in last Proceedings of the M. M. Association.

RECOMMENDATION NO. 17.

Substitute present cuts of 60,000-lb., 80,000-lb. and 100-000-lb. capacity chilled cast-iron wheels with cuts as shown on attached drawing, Exhibits M-1, M-2 and M-3. [Not reproduced.—Editor.]

RECOMMENDATION NO. 18.

Adopt standard tire fastening for steel-tired engine and tender truck wheels, same as shown on drawing, Exhibit L.

The report is signed by:—W. Garstang (C. C. C. & St. L.), chairman; W. C. A. Henry (P. R. R.); A. E. Manchester (C. M. & St. P.); R. L. Ettenger (Southern); J. A. Pilcher (N. & W.) and O. C. Cromwell (B. & O.).

DISCUSSION.

William Garstang (C. C. C. & St. L.): There is a question in regard to the special contour of the wheel. Dr. Dudley, in his research for defects in rails and their causes, is of the opinion that with our one in 20 contour, that the greatest part of the load is carried on the inside of the rail, and due to this it is creating fractures in the ball of the rail which is largely due to the present contour. He suggested that the matter be brought before the convention for the purpose of giving it due and full consideration, and also if it would not be better to go back to our old contour of 1 in 38. I present this matter at this time so that it may be considered with the balance of the paper.

In the second paragraph you will notice that reference is made to cast-iron wheels for 140,000 lbs. capacity. We have on exhibition at this convention, some of the wheels referred to, and I think that it is pretty generally known that there is quite a large number of these wheels now in service. While the wheel is new, and there is no perceptible wear in the tread, the thick flange that appears on these wheels will pass through all frogs and crossings and clearances without interference. But as the tread becomes worn, ⅛ in. or more, there will be an interference. Insofar as I have been able to learn, there have been no bad or serious results which have occurred from that interference. The question is now being considered by manufacturers of chilled wheels and also by the M. C. B. Association, with a view of taking the matter up with the American Railway Association for the purpose of having the clearances, frogs, switches and crossings changed from 1¾ in. as a standard, to 1⅞ in. as may be required. I personally feel that if you can get the American Railway Association to do that, that the cast-iron wheel can be made so as to carry the heaviest load contemplated at the present time with perfect safety.

The report of the committee was referred to letter ballot for adoption of the various recommendations made by the committee as recommended practice.

TESTS OF SUPERHEATER LOCOMOTIVES.

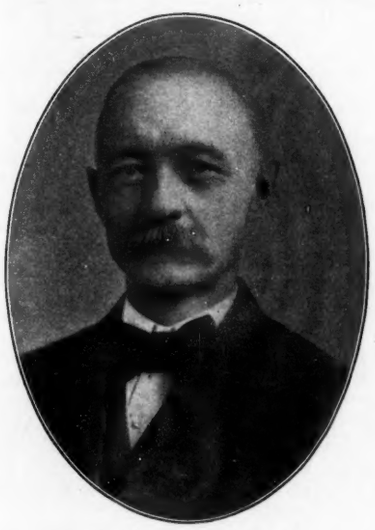
By C. H. Benjamin, and L. E. Endsley.

INTRODUCTION.

The work reported to the association in 1911, showed a comparison of locomotive performance under different degrees of superheated steam. The Schmidt superheater was the last one which was installed. The work this year is a continuation of that accomplished upon the Schmidt superheater and shows the

increased power of the superheater locomotive over the ordinary locomotive when both are using the same amount of coal. Last year a brief statement of the progress of the work was made, but no definite results were given. It was stated at that time that plans were under way to get a larger set of cylinders for the Purdue locomotive. This, however, was not done, and so the report this year only gives the increased power produced by superheating with the same sized cylinder. The work as outlined for the use of larger cylinders remains yet to be carried out at a future time.

Equipment.—The locomotive known as Schenectady No. 2, for the saturated tests, and No. 3, for the superheated tests, was used in all the work. When used with saturated steam the locomotive was in normal condition. When the Schmidt superheater was installed the number of 2-inch tubes was reduced from 200 to 107, and 21 5-inch flues were installed. The original



C. H. BENJAMIN,

Paper on Tests of Superheater Locomotives.

water-heating surface in Schenectady No. 2 was 1,322 square feet. The change in the tubes made necessary by the installation of the Schmidt superheater reduced the water-heating surface to 1,080 square feet. The heating surface of the Schmidt superheater is 324 square feet, making a total water and superheating surface of 1,404 square feet for Schenectady No. 3 after it was equipped with the Schmidt superheater. The nominal dimensions of Schenectady No. 3 as used in the tests with the Schmidt superheater installed are as follows:

Type	4-4-0
Total weight (pounds), about	109,000
Weight on four drivers (pounds), about	61,000
Driving-axle journals:	
Diameter (inches)	7½
Length (inches)	8½
Drivers, diameter (inches)	68.99
Valves (type, Richardson balanced):	
Maximum travel (inches)	6
Outside lap (inches)	1⅛
Inside lap (inches)	0
Ports:	
Length (inches)	12
Width of steam port (inches)	1.5
Width of exhaust port (inches)	3
Total wheel base (feet)	23
Rigid wheel base (feet)	8.5
Cylinders:	
Diameter (inches)	16
Stroke (inches)	24
Boiler (style, extended wagon top):	
Diameter of front end (inches)	52
Number of 2-inch tubes	107
Number of 5-inch flues	21
Length of tubes (feet)	11.5
Heating surface in tubes (square feet)	956.5
Heating surface in fire box (square feet)	123.5
Total water-heating surface (square feet)	1080 0
Length of firebox (inches)	72.06
Width of firebox (inches)	34.25
Depth of firebox (inches)	79
Grate area (square feet)	17
Thickness of crown sheet (inches)	7/16
Thickness of tube sheet (inches)	9/16
Thickness of side and back sheet (inches)	⅜
Diameter of stay bolts (inches)	1
Diameter of radial stays (inches)	1⅛

The Schmidt superheater, as used in these experiments, has the following dimensions:

Outside diameter of superheater pipe (inches)	1⅜
Number of double return loops	21
Average length of the pipes in the double return loops (feet)	42.88
Total superheating surface, based on the outside surface of the pipes in square feet	324

The fuel used in all the tests, both superheated and saturated, was Youghiogheny lump. Repeated analyses of this coal show it to have a very uniform heat value.

TESTS USING SATURATED STEAM.

The Tests Involving Saturated Steam, which were used in this report, were taken directly from Tables IV and V in the report of Dean W. F. M. Goss to the association in 1909. All the tests were run at a speed of 30 miles per hour, and steam pressures of 200, 160 and 120 pounds. The conditions of pressure and cut-off under which the tests were run are shown diagrammatically in Fig. 1. The cut-off is determined by the position of

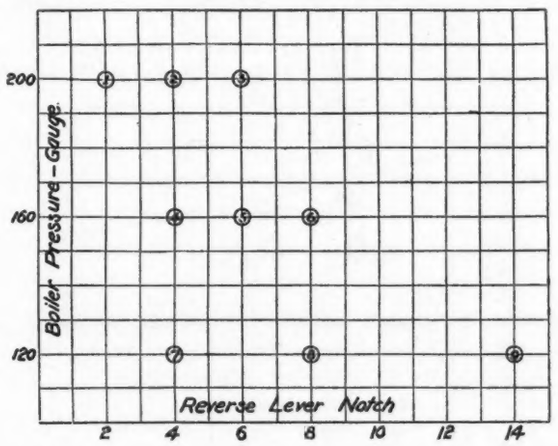


Fig. 1—Showing Conditions of Pressure and Cut-off for the Engine Using Saturated Steam.

the reverse lever in notches. Each circle represents a test, and the number within the circle refers to the laboratory number by which the tests are identified. The results of the tests involving saturated steam are shown in Tables I and II.

Performance of the Boiler.—In the 1909 report of Dean Goss, the relation between the equivalent evaporation per pound of

Table I.

Number	Laboratory Symbol	Speed miles per hour	Dry Coal per Sq. ft. of Grate Surface per hr.	Smoke Box Temperature Degrees F.	Equiv. Evap. per Sq. ft. Heating Surface per hr. Pounds	Equiv. Evap. per pound of Coal	Cut Off Per Cent of Stroke	M. E. P. pounds per Sq. inch	Indicated Horse Power	Pounds of Steam per I.H.P. per Hour	Pounds Coal per I.H.P. Hour	Draw Bar Pull Pounds	Draw Bar Horse Power
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	VIII	XIII
1	30-2-200	30.0	55.0	673	6.96	9.82	14.19	37.88	268.9	27.01	3.48	2965	237.4
2	30-4-200	30.0		682	8.56		10.87	31.69	367.1	25.70		3847	307.4
3	30-6-200	30.0	98.0	766	11.12	8.83	26.75	68.90	489.2	24.91	3.40	5380	430.1
4	30-4-160	29.9	51.9	662	6.60	9.89	17.84	38.39	272.1	26.66	3.24	2655	211.9
5	30-6-160	30.0	68.9	707	8.75	9.87	25.67	54.08	383.9	25.28	3.05	3786	302.5
6	30-8-160	30.0		763	10.91		33.06	65.58	465.1	25.69		5130	410.9
7	30-4-120	30.0	35.4	606	4.70	10.32	17.62	24.09	171.0	30.63	3.52	1277	102.1
8	30-8-120	30.1	65.6	676	7.99	9.77	32.79	45.82	325.5	27.46	3.32	3569	285.5
9	30-14-120	29.9	130.7	835	13.99	8.38	56.85	72.56	514.0	30.31	4.28	6256	500.6

dry coal and the equivalent evaporation per square foot of heating surface per hour for the locomotive using saturated steam is shown by the equation $E = 11.305 - .221\ H$, in which E is the equivalent evaporation per pound of dry coal and H is the equivalent evaporation per square foot of heating surface per hour. This equation is assumed to represent the evaporative

Table II.

Number	Laboratory Symbol	Equiv. Steam for Engine per Hour Pounds Water at 212° F.	Equiv. Evap. per Pound Dry Coal Pounds Dry Coal	Dry Coal per Hr. per Sq. Ft. Grate Surface	Dry Coal per Sq. Ft. Outside Surface per Hr. Pounds	Dry Coal per I.H.P. per Hr.	Equiv. Steam per I.H.P. per Hr.	Machine-Friction: Mean Effective Pressure	Machine-Friction: Indicated Horse-Power	Machine-Friction: Per Cent I.H.P.	Dynamometer Horse-Power	Draw Bar Pull	Coal per Draw Horse Power per Hr.	Equiv. Steam per Draw Horse Power per Hour
I	II	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	XXIV	XXV	XXVI
1	30-2-200	8768	9.058	891	58.4	3.31	32.60	6.5	46.1	17.1	222.0	2760	4.00	39.58
2	30-4-200	11356	9.406	1207	71.0	3.29	30.92	8.6	60.4	16.4	306.7	3830	3.93	37.08
3	30-6-200	14685	8.850	1658	97.6	3.39	30.00	9.3	66.9	13.5	423.2	5290	3.98	34.70
4	30-4-160	8705	9.836	893	52.5	3.38	32.26	8.5	60.4	22.2	211.7	2640	4.22	41.50
5	30-6-160	11663	9.355	1246	73.3	3.25	30.34	9.3	66.0	17.2	317.9	3970	3.92	36.69
6	30-8-160	14547	8.906	1611	94.8	3.46	30.85	8.4	59.8	12.8	405.6	5070	3.97	35.59
7	30-4-120	6269	10.257	611	35.9	3.57	36.69	8.5	60.4	35.4	118.6	1580	5.52	50.68
8	30-8-120	10683	9.349	1122	66.0	3.45	32.00	8.4	59.6	16.3	265.9	3320	4.22	40.18
9	30-14-120	18654	8.106	2278	134.0	4.45	36.29	9.0	81.3	4.1	492.7	6160	4.52	37.86

efficiency of the boiler when operated under saturated steam. In order to obtain the relation between the equivalent evaporation per pound of dry coal and the rate of firing, an equation was obtained in the following manner: Letting G equal the dry

coal per square foot of grate surface per hour, 1,322 is the number of square feet of water-heating surface, 17 the number of square feet of grate surface, and H and E the same as above mentioned. Now, from the above values, the following equation is true: $1{,}322\ H = 17\ E\ G$, or $H = \frac{17\ E\ G}{1{,}322}$

Substituting this value of H in the equation $E = 11.305 - .221\ H$, we obtain the equation $E = \frac{3{,}978}{G + 351.9}$

This equation gives the relation between equivalent evaporation per pound of dry coal and the dry coal per square foot of grate surface per hour when using saturated steam. The graphical representation of this equation is shown in Fig. 2.

Performance of Original Locomotive Assuming Irregularities to Have Been Eliminated.—Table II shows the performance of the locomotive, assuming irregularities due to boiler performance to have been eliminated. The results in this table were obtained as follows:

Column XV, which gives equivalent steam supplied to locomotive per hour with feed-water at 60° F., equals pounds of

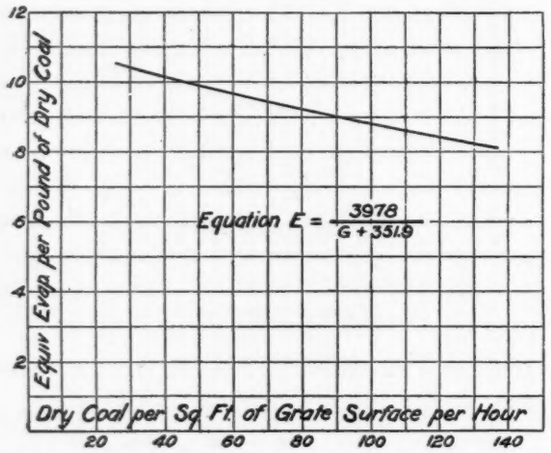


Fig. 2—Showing Relation between Equivalent Evaporation per Pound of Dry Coal and Dry Coal per Sq. Ft. of Grate Surface per Hour for the Engine Using Saturated Steam.

steam supplied to locomotive per hour from original log multiplied by (B. t. u. taken up by each pound of steam minus [60 minus feed-water temperature]) divided by 970.4 (latent heat of evaporation).

Column XVI, which gives the equivalent evaporation per pound of dry coal corrected by equation, was obtained by substituting the values in column VI, Table I, for H in the equation $E = 11.305 - .221\ H$.

Column XVII, which gives dry coal fired per hour corrected by equation, equals column XV divided by column XVI.

Column XVIII, which gives dry coal per square foot of grate surface per hour, equals column XVII divided by 17 (the number of square feet of grate surface).

Column XIX, which gives dry coal per indicated horse-power per hour, equals column XVII divided by column X in Table I.

Column XX, which gives the equivalent steam per indicated horse-power per hour, equals column XV divided by column X in Table I.

Column XXI, which gives the machine friction in terms of mean effective pressure, was taken from Fig. 13, page 158, of the 1909 report of Dean Goss.

Column XXII, which gives the machine friction in horse-power, is obtained by using the values of M. E. P. of column XXI and the speed in revolutions per minute of the individual test, together with the indicated horse-power constant of the locomotive.

Column XXIII, which gives the machine friction in per cent. of indicated horse-power, equals column XXII divided by column X in Table I and multiplied by 100.

Column XXIV, which gives dynamometer horse-power, equals column X in Table I minus column XXII in Table II.

Column XXV, which gives the drawbar pull, equals column XXIV divided by (.000547 multiplied by the revolutions per minute), in which .000547 is the tractive horse-power constant of the locomotive.

Column XXVI, which gives the coal per dynamometer horse-power per hour, equals column XVII divided by column XXIV.

Column XXVII, which gives the equivalent steam per dynamometer horse-power per hour, equals column XV divided by column XXIV.

TESTS USING SUPERHEATED STEAM.

The tests involving superheated steam, as run on Schenectady No. 3, were at a speed of 30 miles an hour, at the same pressures as were used on the original locomotive—that is, 200, 160 and 120 pounds. The conditions of pressure and cut-off under which the tests were run are shown diagrammatically in Fig. 3, in which the cut-off is determined by the position of the reverse lever notch. Each circle represents a test, and the

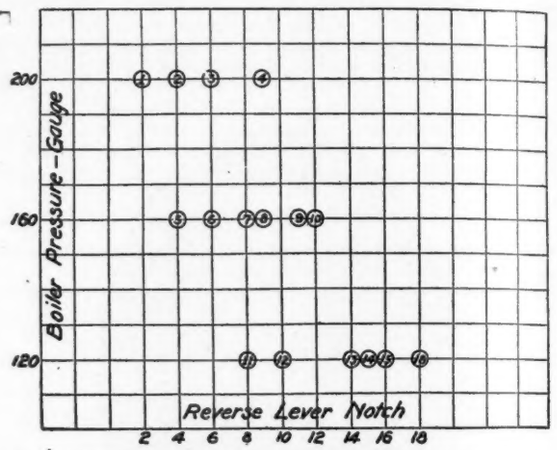


Fig. 3—Showing Conditions of Pressure and Cut-off for the Engine Using Superheated Steam.

number written in the circle represents the laboratory number by which the tests are identified. The results of tests under superheated steam are shown in Tables III and IV. It will be seen that the reverse lever was carried to a higher notch than with the saturated steam.

Performance of the Boiler.—The equivalent evaporation per

Table III.

Number	Laboratory Symbol	Speed Miles per Hour	Dry Coal per Sq. Ft. Grate Surface per Hr. Lbs.	Smoke Box Temp. Degrees F.	Degrees Superheat	Equiv. Evap. per Sq. Ft. of Heating Surface per Hr. Pounds	Equiv. Evapor. per Lb. of Dry Coal	Cut-Off Per Cent of Stroke	M. E. P. pounds per Sq. In.	Indicated Horse-Power	Pounds of Steam per I.H.P. per Hr.	Pounds of Coal per I.H.P. per Hr.	Draw-Bar Pull	Draw-Bar Horse-Power
I	II	III	IV	V	Va	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
1	30—2—200	30.3	46.2	558	187.0	6.08	10.40	17.87	41.42	2982	21.30	2.02	2000	2269
2	30—4—200	30.1	62.1	622	222.0	7.79	10.38	31.35	61.47	4381	17.88	2.41	4499	3614
3	30—6—200	28.9	82.6	657	246.2	9.20	9.20	57.45	74.82	5285	17.49	2.67	5702	4528
4	30—9—200	30.0	127.3	714	238.5	12.42	8.06	49.56	97.34	6964	18.64	3.11	7454	5967
5	30—4—160	30.0	44.5	579	201.6	6.01	10.70	21.00	44.90	3172	18.56	2.50	3282	2612
6	30—6—160	30.0	59.2	609	226.3	7.30	10.20	30.00	55.30	3960	18.77	2.35	4165	3343
7	30—8—160	30.0	74.4	610	245.6	8.88	9.86	38.00	69.06	4907	18.38	2.58	5293	4233
8	30—9—160	29.6	92.7	627	270.3	9.85	8.78	44.65	77.39	5464	18.67	2.90	5945	4378
9	30—11—160	30.0	109.3	682	253.1	11.70	8.84	52.40	86.90	6151	19.75	3.02	6664	5328
10	30—12—160	28.9	124.2	642	244.3	12.30	8.18	56.82	93.41	6435	20.09	3.26	7199	5536
11	30—8—120	30.0	59.6	583	229.6	7.03	9.77	38.99	47.59	3432	21.30	2.95	3845	3088
12	30—10—120	30.0	65.0	584	243.9	8.06	9.76	44.15	59.37	4187	20.14	2.64	4702	3748
13	30—16—120	30.0	96.9	629	277.1	10.86	8.93	59.84	72.19	5114	21.52	3.21	5856	4687
14	30—15—120	31.2	103.3	665	305.1	11.68	9.34	60.48	74.08	5488	21.67	3.20	5288	4413
15	30—16—120	30.0	110.3	696	293.1	11.71	8.76	64.45	78.42	5557	22.54	3.50	6157	4910
16	30—18—120	29.9	121.7	726	284.0	12.85	8.79	73.08	77.79	5506	24.30	3.76	6342	5014

square foot of water and superheating surface per hour and the equivalent evaporation per pound of dry coal, Columns VI and VII in Table III, were plotted as shown in Fig. 4. There were sixteen different tests run under superheated steam, and, as

Table IV.

Number	Laboratory Symbol	Equiv. Steam per Engine per Hour Deg. Feed Water 60°	Equiv. Evap. per Sq. Ft. Heating Surface per Hr.	Dry Coal Fired per Hr. Corr. by Equation	Dry Coal per Sq. Ft. Grate Surface per Hr. Pounds	Dry Coal per I.H.P. per Hr.	Equiv. Steam per I.H.P. per Hr.	Machine-Friction: Mean Effective Pressure	Machine-Friction: Indicated Horse Power	Machine-Friction: Per Cent I.H.P.	Dynamometer Horse-Power	Draw-Bar Pull	Coal per Dyna. Horse Power per Hr.	Equiv. Steam per H.P. per Hr.
I	II	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	XXIV	XXV	XXVI	XXVII
1	30—2—200	8307	10.50	600	42.1	2.76	28.94	6.5	46.5	16.00	243.7	3017	3.28	34.45
2	30—4—200	10737	8.96	1078	63.4	2.46	24.50	8.5	60.2	13.70	377.9	4706	2.85	28.42
3	30—6—200	12817	8.31	1348	79.4	2.55	24.25	9.3	65.2	12.30	463.3	5840	2.91	27.67
4	30—9—200	17435	8.48	2056	120.9	2.95	25.04	7.7	54.7	7.90	641.7	8018	3.20	27.17
5	30—4—160	8349	10.83	793	46.6	2.50	26.92	6.5	45.7	14.40	271.3	3415	2.92	30.75
6	30—6—160	10050	10.11	995	58.5	2.53	26.91	8.6	60.2	13.50	335.8	4182	2.96	30.14
7	30—8—160	12378	9.61	1267	75.7	2.62	25.82	9.3	65.7	13.40	428.0	5380	3.03	29.12
8	30—9—160	13635	9.39	1458	87.5	2.73	25.41	7.7	54.0	9.90	494.4	6217	3.03	28.81
9	30—11—160	16484	8.71	1886	114.9	3.07	26.70	6.0	42.6	6.90	572.5	7161	3.29	28.69
10	30—12—160	17276	8.58	2027	119.2	3.15	26.64	5.0	34.2	5.50	609.3	7617	3.33	28.36
11	30—8—120	9335	10.20	976	57.5	2.84	26.96	8.6	59.5	17.30	283.6	3533	3.45	32.92
12	30—10—120	11456	9.61	1168	68.7	2.78	27.30	6.9	48.5	11.70	371.2	4666	3.15	30.86
13	30—16—120	15163	8.88	1691	98.6	3.31	29.69	3.0	21.2	4.20	490.8	6112	3.45	30.98
14	30—15—120	16399	8.72	1881	110.6	3.43	29.86	3.0	22.2	4.00	526.6	6536	3.57	31.14
15	30—16—120	16436	8.71	1867	111.0	3.52	30.66	3.0	21.3	4.00	514.4	6311	3.67	31.95
16	30—18—120	18186	8.31	2188	128.7	3.97	33.03	3.0	21.2	3.90	588.4	8123	4.15	34.55

shown, each point represents one test. The equation for the line as shown, which most nearly approximates all the points, is $E = 12.443 - .319\ H$, where E is the equivalent evaporation

per pound of dry coal and H is the equivalent evaporation per square foot of water and superheating surface per hour. The area of the heating surface is based upon the interior surface of the firebox and the exterior surface of the boiler and superheating tubes. This equation was derived from all tests at all pressures and therefore fairly represents the average performance of the boiler at any pressure when operated under superheated steam. It is a noteworthy fact that this equation is practically the same as that obtained from the lower rates of firing reported to the association in 1911. The equation for the nine points as obtained that year was $E = 12.450 - .318\ H$. In the same manner as used in the original locomotive, G equals the dry coal per square foot of grate surface per hour, 1,404 the number of square feet of water and superheating surface, 17 the number of square feet of grate surface and H and E the same as before mentioned, the following formula is true: $1{,}404\ H = 17\ E\ G$, or $H = \frac{17\ E\ G}{1{,}404}$

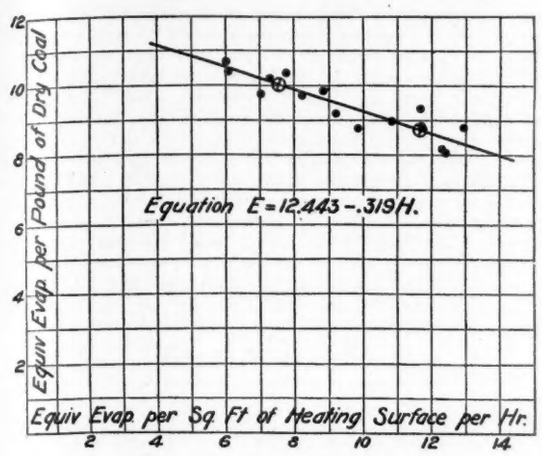


Fig. 4—Showing Relation between Equivalent Evaporation per Pound of Dry Coal and Equivalent Evaporation per Sq. Ft. of Heating Surface per Hour for the Engine Using Superheated Steam.

Substituting this value of H in the equation $E = 12.443 - .319\ H$, we obtain the equation $E = \frac{3{,}221}{G + 258.9}$, which shows the relation between the equivalent evaporation per pound of dry coal and the dry coal per square foot of grate surface per hour when using superheated steam. The graphical representation of this equation is shown in Fig. 5.

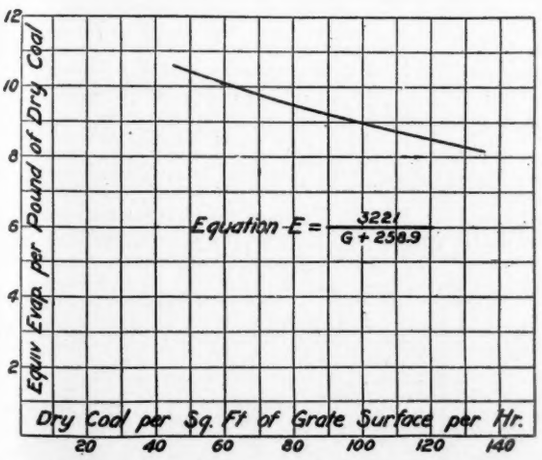


Fig. 5—Showing Relation between Equivalent Evaporation per Pound of Dry Coal and Dry Coal per Sq. Ft. of Grate Surface per Hour for the Engine Using Superheated Steam.

Performance of the Superheated Locomotive, Assuming Irregularities to Have Been Eliminated.—Table IV shows the performance of the locomotive when using superheated steam, assuming irregularities to have been eliminated. The results in this table were obtained in exactly the same manner as those from the locomotive when using saturated steam as shown in Table II, and may be compared with them.

THE INCREASE OF POWER OF THE SUPERHEATER LOCOMOTIVE OVER THE ORIGINAL LOCOMOTIVE WHEN USING THE SAME AMOUNT OF COAL.

Having now obtained the values as shown in Tables II and IV for the two types of locomotives, the curves as shown in Figs. 6 to 9 were plotted. By the use of the equations of the curves in Figs. 2 and 5, the equivalent pounds of steam per pound of coal can be determined for any rate of firing of either locomotive. Also, from Figs. 6 and 7, the equivalent pounds of steam per I. H. P. per hour can be determined for any cut-off, and from the lines shown in Figs. 8 and 9 the mean effective pressure for any cut-off can be ascertained. Now, assuming that the curves as shown in these figures fairly represent the performance of each locomotive, it is possible to obtain the performance of each locomotive at the same rate of firing—that is, burning the same number of pounds of coal per square foot of grate area per hour. Table V shows this comparison of the two locomotives while burning 110, 120 and 130 pounds of coal per square foot of grate.

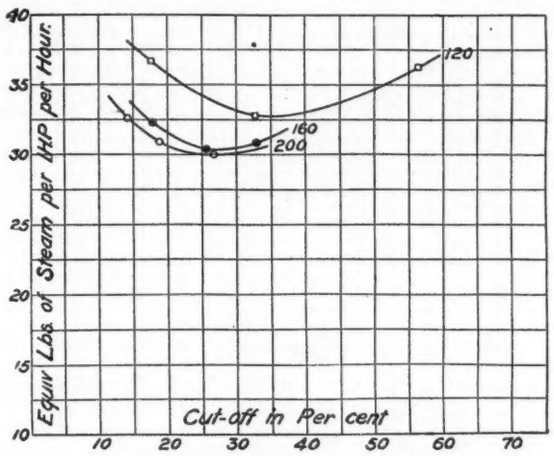


Fig. 6—Showing Relation between Equivalent Pounds of Steam per I.H.P. per Hour and Cut-off for the Engine Using Saturated Steam.

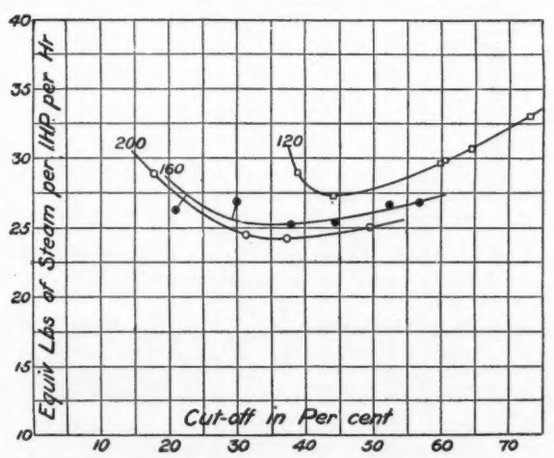


Fig. 7—Showing Relation between Equivalent Pounds of Steam per I.H.P. per Hour and Cut-off for the Engine Using Superheated Steam.

Column I of this table shows the rate of firing per square foot of grate per hour.

Column II gives the steam pressure, the comparisons being made at three pressures, namely, 200, 160 and 120.

Column III gives the equivalent evaporation per pound of dry coal for the original locomotive, and was obtained by substituting the values in column I for G in the equation $E = \frac{3{,}978}{G + 351.9}$

Column IV gives the equivalent evaporation per pound of dry coal for the superheater locomotive, and was obtained by sub-

stituting the values in column I for G in the equation

$$E = \frac{3{,}221}{G + 258.9}$$

Column V gives the equivalent pounds of steam per hour for the ordinary locomotive, and was obtained by multiplying the

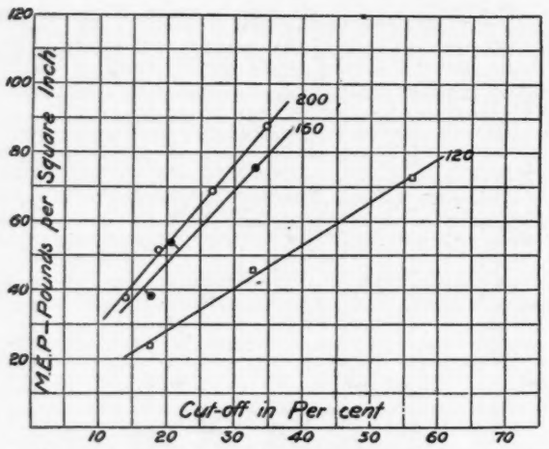


Fig. 8—Showing Relation between M. E. P. and Cut-off for the Engine Using Saturated Steam.

values in column I by those in column III and then by 17.

Column VI gives the equivalent pounds of steam per hour for the superheater locomotive, and was obtained by multiplying the values in column I by those in column IV and then by the grade area, which is 17 square feet.

Columns VII to XIV were obtained in a "cut and try" method,

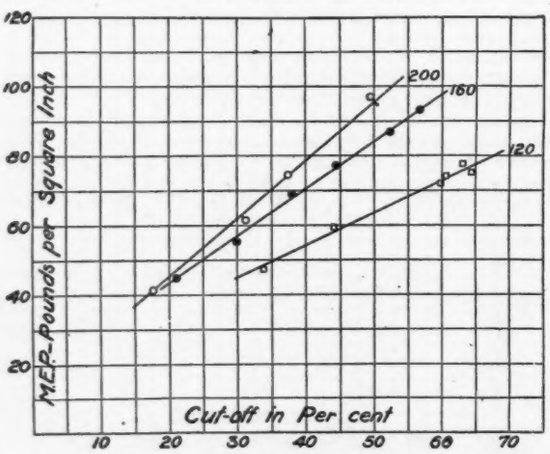


Fig. 9—Showing Relation between M. E. P. and Cut-off for the Engine Using Superheated Steam.

which is shown by the following example: When using 110 pounds of coal per square foot of grate area under a steam pressure of 200 pounds, we get at a 48 per cent. cut-off;

From the curve in Fig. 7, 24.9 pounds of steam per I. H. P. per hour;

Table V.

Dry Coal per Sq. Ft. of Grate Surface per Hour	Steam Pressure	Equiv. Evap. per Pound of Dry Coal		Equiv. Pounds of Steam per Hour		Cut-Off in Per cent		Equiv. Pounds of Steam per I.H.P. per Hr.		M.E.P. Lbs. per Sq. In.		Indicated Horse Power		Per cent Increase in I.H.P.
		Sat.	Sup.	Sat.	Sup.	Sat.	Sup.	Sat.	Sup.	Sat.	Sup.	Sat.	Sup.	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.
110	200	8.61	8.73	16100.7	16325.1	29.5	48.1	34.1	24.9	76.3	92.4	534.8	655.6	22.6
110	160	8.61	8.73	16100.7	16325.1	32.3	52.4	30.7	26.4	73.8	87.1	524.3	618.4	18.0
110	120	8.61	8.73	16100.7	16325.1	42.9	63.05	34.7	30.3	65.4	75.8	464.2	538.5	16.0
120	200	8.45	8.50	17197.2	17540.0	31.6	50.9	38.3	25.2	80.0	96.9	567.8	688.1	21.2
120	160	8.45	8.50	17197.2	17540.0	34.3	56.6	34.1	26.7	77.9	91.5	553.1	689.6	17.5
120	120	8.45	8.50	17197.2	17540.0	52.6	68.96	35.3	31.1	68.6	78.5	487.2	557.6	14.4
130	200	8.25	8.28	16232.5	16298.8	33.4	55.2	36.6	26.5	84.2	101.9	597.6	717.4	20.0
130	160	8.25	8.28	16232.5	16298.8	36.0	58.2	31.5	27.1	81.5	95.1	578.6	675.2	16.7
130	120	8.25	8.28	16232.5	16298.8	44.9	64.7	36.8	31.8	71.7	81.0	508.2	575.3	13.0

From the line in Fig. 9, 92.2 pounds mean effective pressure.

Thus, I. H. P. $= \frac{16325.1}{24.9} = 655.6.$

Also, I. H. P. $= 4\ (92.2)\ (.012144)\ (146.2) = 654.6.$

At 48.2 per cent. cut-off we obtain from the curves in Fig. 7 24.9 pounds of steam per I. H. P. per hour, which gives I. H. P. = 655.6, and from the curves in Fig. 9 92.7 mean effective pressure, which gives I. H. P. = 658.2.

By looking at the above sets of values, it can be seen that at 48 per cent. cut-off the I. H. P. figured from the basis of pounds of steam per I. H. P. is greater than that figured from the basis of the M. E. P., and at 48.2 per cent. cut-off just the reverse is true. Therefore, the proper values must lie somewhere between 48 and 48.2 per cent. cut-off.

The proper value of 48.1 per cent. cut-off was found to give the same I. H. P. figured from the pounds of steam per I. H. P. per hour as figured from M. E. P.; that is, with 48.1 per cent. cut-off, the steam per I. H. P. per hour is 24.9 as obtained from the curve and gives an I. H. P. of 655.6. The M. E. P. at this cut-off is 92.4, and gives an I. H. P. of 656.0. These are so near the same that the 655.8 value was taken as the I. H. P. developed while burning 110 pounds of coal per square foot of grate. The four values mentioned above were used in the tables. The same process was used in determining the values for each line of Table V.

Column XV of Table V, which gives the per cent. increase in indicated horse-power of the superheater locomotive over the other locomotive, when using the same amount of coal, equals column XIV minus column XIII divided by column XIII and multiplied by 100.

DISCUSSION OF RESULTS.

Increased Power Due to Superheating.—It can be seen from Column XV, Table V, that the increase in power due to superheating, when burning from 110 to 130 pounds of coal per square foot of grate surface per hour, varies from 22.6 to 13.0 per cent. Also from the values in this column it can be seen that for any steam pressure the per cent. increase of power decreases as the coal consumption increases, and that for any coal consumption, the increase of power increases as the steam pressure increases.

The Effect of Increasing Size of Cylinder for Maximum Power.—By comparing the values of equivalent pounds of steam per I. H. P. per hour it will be seen that they are considerably

Table VI—Superheater Engine 120 Pounds Dry Coal per Sq. Ft. of Grate Surface per Hour.

Steam Pressure	Cut-Off in Percent of Stroke	Equiv. Lbs. of Steam per I.H.P. per Hr.	M.E.P. Pounds per Sq. Inch	Cut-Off at Maximum Efficiency	Equiv. Lbs. of Steam per I.H.P. per Hr. at Maximum Efficiency	M.E.P. at Maximum Efficiency	Percent Increase in I.H.P.	Diam. of Cyl. in Inches to give Maximum Efficiency
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
200	50.9	25.2	96.9	35.0	24.2	70.0	3.97	18.82
160	55.5	26.7	91.5	37.0	25.2	66.7	5.62	18.73
120	65.95	31.1	76.5	44.0	27.3	58.0	12.22	18.62

larger than the best performance of the locomotive as obtained at a lower cut-off; that is, the cut-off of maximum efficiency for 160 pounds steam pressure is approximately 37 per cent., while the cut-off as obtained under 120 pounds of coal per hour is 55.5 per cent. The relative steam consumption for these two values of cut-off is 25.2 and 26.7 pounds per I. H. P. per hour, respectively. It will be seen that the increase in power to be accomplished by having the cut-off at the proper point to give maximum efficiency is about 5.6 per cent., as is shown in column VIII. That is, $\frac{26.7 - 25.2}{26.7} \times 100 = 5.6$ per cent. In order to show this more clearly, the values in Table VI have been worked out.

Columns I, II, III and IV were taken from columns II, VIII, X and XII, respectively, in Table V, at 120 pounds of dry coal

Table VII.

Steam Pressure	I H P		Per Cent Increase in I H P
	Sat	Sup	
200	567.8	217.0	26.3
160	553.1	689.0	24.5
120	487.2	636.0	30.0

per square foot of grate surface per hour. The values in column V, which give the cut-off at maximum efficiency, were taken at the lowest points of the curves in Fig. 7. The values in column VI, which give the equivalent pounds of steam per I. H. P. per hour at maximum efficiency, were taken from the curves in Fig. 7 at the points of cut-off shown in column V. The values in column VII, which give the M. E. P. at maximum efficiency, were taken from the curves in Fig. 9 at the points of cut-off shown in column V. The values of column VIII, which give the per cent. increase in indicated horse-power, equals column III minus column VI divided by column III and multiplied by

100. The values in column IX, which give the diameter of cylinders necessary to obtain maximum efficiency, equal sixteen times the square root of values given in column IV divided by the square root of values given in column VII. The following sample calculation will show this more clearly. The diameter of the cylinders at present is 16 inches. The ratio of this to the new diameter required to give the same indicated horsepower must be inversely proportional to the square roots of the mean effective pressures. For 200 pounds pressure

$$\frac{X}{16} = \frac{\sqrt{96.0}}{\sqrt{70.0}} = \frac{9.86}{8.38}$$

$$X = 18.82$$

where X is the new diameter of cylinder.

The average of the three values in column IX is about 18¾ inches. Now, if the locomotive were equipped with 18¾-inch cylinders, when using 120 pounds of coal per square foot of grate, the cut-off could be at the most efficient point to obtain maximum power.

Under these conditions there would be an increase in power as shown in Table VII, or, in other words, the increase in power of the superheater locomotive over the other for the 160 and 200 pounds pressure would be about 25 per cent. if the size of the cylinders were increased to 18¾ inches, whereas at present the increase is about 20 per cent.

Table VII, showing the increase of power of the superheater locomotive over the other when using 120 pounds of coal per square foot of grate per hour if the cylinders were increased to 18¾ inches, is given below.

DISCUSSION.

C. D. Young (Penna.): As Professor Benjamin has said, we have both arrived at about the same destination by different means. The facts could not be otherwise, owing to the physical laws with which we were both working. There are two or three points in the paper to which I would like to call the attention of the membership, that in degree only differ from the results which we have obtained. In referring to diagram 5, from which it has been determined what would be the proper size of cylinders, the coal burning rate per square foot of grate when plotted against the equivalent evaporation per lb. of dry coal is slightly higher for the superheated than for the saturated. For example, for 80 lb. rate, the diagram shows it would be in the neighborhood of 9¼ for the superheated locomotive, and about 9.3 for the saturated locomotive. All of our experience has indicated that the application of the superheater at a good burning rate, will reduce the equivalent evaporation per lb. of dry coal. In other words, we can expect less efficiency by the boiler alone, whereas the data shows that the superheated steam boiler has higher efficiency than the saturated steam boiler. The diagrams in the Committee's report are 24, where at 80 lbs. the E-6 locomotive gave when superheated, 9.4, and when saturated, 10 lbs. equivalent of water per lb. of dry coal. That has been all the difference we found due to the application of the superheater to the boiler.

All of Prof. Benjamin's tests were run at 30 m. p. h., and I do not think it is fair to make determinations on the results of one speed in the volume of cylinder. A saturated steam engine will give a given water rate at 30 m. p. h. which will probably be comparable with its cylinder volume, whereas at speeds of 60 to 75 m. p. h., you get the best rates from a passenger locomotive; freight at 30 miles, you are only getting the average superheat as compared with about as good as you can get from the saturated steam locomotive; therefore it would be well to consider a range of speed in making your water rates; for if you disregard these, you make the increase too small in the cylinder volume to get the maximum value.

J. E. DeVoy (C. M. & St. P.): We have under consideration the equipping of saturated engines with superheaters, and the opinion we have formed since coming here makes it that it would be better to throw away the present cylinders and increase the diameter of the cylinders, rather than try to say, bore them out one inch.

L. H. Fry: One point Mr. Young made in regard to the efficiency of the saturated boiler as compared with the superheated boiler can be applied to the locomotive. I believe this can be explained by the fact that the superheater boiler takes more air than the saturated boiler. I have followed the Purdue University test and it seems that in this particular engine, the application of the superheater reduced the resistance of the boiler to the passage of the air. The Purdue Superheater engine takes more air than the saturated, while in the Pennsylvania test the reverse is the case.

W. C. A. Henry (Penna.): We have a saturated engine with 20 in. cylinders, and when we apply superheater, I hope to get more fuel economy out of the change. These locomotives are now double-headed to a considerable extent owing to the increase in the weight of trains and fast schedules; so in working up plans, we made new drawings calling for a cylinder of 2 in. greater diameter than the ones that we used before. We hope to realize this increase in starting and in horse-power by so doing.

E. W. Pratt (C. & N. W.): On the North Western we had a number of the Pacific type engines, some of which were saturated and some superheated, and at the present time all the saturated engines have been changed, without enlarging the cylinders. We have not made any careful tests, but the results in operation appear to be a considerable saving of fuel and a livelier engine, by maintaining the same cylinder and fixing the boiler pressure to 185 lbs. In heavy trains, the 2 in. larger cylinder, superheated engine, with less pressure does the business more economically. That is the practical standpoint, covering our experience with over 100 locomotives.

F. F. Gaines: From a preliminary study of the two reports, it is indicated that larger cylinders point to larger economy, and going into that we will find at maximum cut-off we will have an engine with low adhesive factors.

C. D. Young: I think we will establish a diameter; but probably you may, with short-stroke engines, be able to increase the volume by increasing the stroke. That will have to be carefully considered in freight engines where the turning torque enters into consideration. As far as the Pennsylvania is concerned, we are increasing the size of cylinders of our freight engines. The first engine was a Consolidation, which had a tractive power of 42,000 saturated; and we have increased the cylinder size to where we obtain about 51,000 lbs. from the same identical boiler. This has been done entirely by an increase in the diameter of the cylinder. Even on exhaust cylinders this can be done, because our original pins and rods were figured with a sufficient factor to take care of the strength at the starting.

Such an engine has been on our test plant and for a freight engine, has given remarkable water rates. We have run the engine as low as 8 m. p. h., on full gear, on the locomotive test plant, something that we were never able to do before, owing to braking troubles, and at 8 m. p. h., we have developed more tractive power than we calculated for at the start, which is a rather remarkable figure, and we have had sufficient capacity in the boiler to operate it full gear up to something like 13 m. p. h. without affecting the steam pressure whatsoever. At these long cut-offs, the water rate is fairly comparable with the old saturated steam water rate, at the more economical cut-off, and when operating at 25 per cent. cut-off we have got as low as 17.8 lb. of water per indicated horse power at slow speed, which shows that the compound superheater is somewhat in the distance.

J. F. DeVoy (C. M. & St. P.): I wish to say a word or two about the factor of adhesion. I believe, and have always thought, that we should take the greatest unit of power out of the locomotives that is possible. We have 80 consolidation engines with a factor of adhesion of 3.91, so that it does not appear to me that we are going to take a very big chance. With an engine built for long grades and sustained effort, we can afford to reduce the factor of adhesion. I am more alarmed about the stress on pins and rods and other things than I am about the factor of adhesion. I am fully convinced that in order to take all the power out of the locomotive that we should take, that we had better consider increasing the size of the cylinders in order to get the best results, so far as efficiency is concerned, and take a chance with the factor of adhesion.

F. F. Gaines: My experience has been that a slippery engine is a costly engine. We have some engines with a factor of adhesion of 3.9, which is around the neighborhood of what Mr. DeVoy speaks of, and we have another class of engines with the same tractive power, but have a higher factor of adhesion, and there is a difference in the maintenance cost of the two types of locomotives; the one with the lower factor of adhesion does slip and wears out the tires and pins and other parts of the locomotive much faster than the heavier engines do, and as a suggestion, possibly, to getting a larger cylinder, I think what might be done would be to block off the reversing lever, so that you could not get the engine down in a corner.

J. F. DeVoy: I wish it to be understood that my opinion is due to the country in which I am engaged in railroad operation.

G. W. Wildin (N. Y., N. H. & H.): There is one point which is brought out, and that is in applying the superheater to your locomotive, you add to the weight of your drivers from 3,000 to 5,000 lbs., which enables you to get a more effective engine by having a larger cylinder. We have some Pacific type engines, with 22 in. x 28 in. cylinders and 200 lb. pressure, which we changed over to superheaters. We retained the pressure and increased the cylinder to 23 in. x 28 in. and we have a 10 per cent. larger engine on the starting capacity and 25 per cent. larger engine on the hauling capacity.

Prof. L. E. Endsley: The design which was brought out

in the last application of the superheater through the Purdue Locomotive, was very carefully worked out so that the reduction in the heating surface made necessary was small in comparison to the size of the firebox. We all know that the firebox does a great deal more work per sq. ft. of heating surface, so that we did not reduce the water-heating surface so very much when we put in the last superheater. By adding the larger superheater with 324 sq. ft. of heating surface, we got a boiler that gave a very high efficiency, possibly higher than you would get today should you redesign any of your present saturated steam boilers. You would not have as much heating surface in your firebox of the boiler today as compared with the Purdue Locomotive. In fact, the last installation as put in with the superheater gave a much higher efficiency of the boiler than on any other superheaters which we have used, and we did not have nearly the total heating surface that we have now.

I do not think you would expect to get any such increased efficiency by the installation in a modern locomotive as Mr. Young described, but it so happened that at Purdue, this engine was built in 1897 for saturated steam and did not have as large a heating surface for the size of the locomotive as you would get today, and that accounts for the increase in the boiler efficiency as compared with the engine of today.

One thing which Mr. Pratt brought out was in relation to the reduction of pressure. I think it is pretty well shown by our tests that the difference in efficiency of the locomotive as a whole between 160 lb. and 200 lb. is small, and that if you do not want to increase the tractive power by increasing the size of the cylinder, you can reduce your pressure and not lose very much in the efficiency of your engine.

Insofar as steam is concerned, these tests were run at 30 m. p. h., that being a speed which gave the minimum steam consumption to the saturated locomotive. In the superheater locomotive, I think you will find, possibly, that it will be about the same.

The boiler efficiency is not affected by steam, it is merely the rate at which you put the coal in the locomotive. If you put it in at a high rate of firing, the efficiency will increase, and if you should attempt to maintain the same cut-off at higher rates, you will increase your coal consumption, and therefore decrease the efficiency of your boiler.

As to the question of added air, I was not able to follow just how we could get more air in. We have practically the same vacuum at the front end, the same area in the flues, practically the same grate areas, and I do not see how we can get any more air through to increase the efficiency. I think whatever increase in efficiency we get in the boiler is due to the firebox, in most of the cases, in both cases, and having enough flue area so that we have a sufficient heating surface. You will not get that in all locomotives, because we are taking advantage of every foot of flue area to get as many flues as we can, today. That was not taken advantage of in the design of the locomotive tested at Purdue under saturated steam.

A vote of thanks was extended to Dean Benjamin and Prof. Endsley for the very competent and able paper which they presented.

CONCLUDING EXERCISES.

The usual resolutions were offered thanking the Railway press in general and the *Railway Age Gazette* in particular for the daily reports of the convention's proceedings.

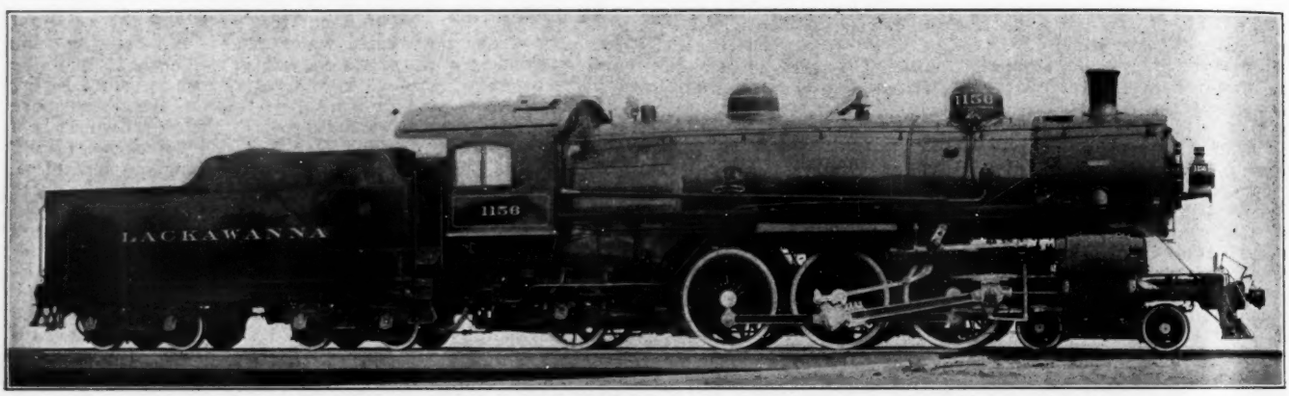
The following officers were elected for the ensuing year: President, D. R. MacBain, (L. S. & M. S.); first vice-president, F. F. Gaines, (Cent. of Ga.); second vice-president, E. W. Pratt, (C. & N. W.); third vice-president, Wm. Schlafge, (Erie), and treasurer, Angus Sinclair. Executive Members for two years: W. J. Tollerton (Rock Island Lines); J. F. DeVoy (C. M. & St. P.), and J. T. Wallis (Penna.). F. H. Clark (B. & O.) was elected for one year.

Scott H. Blewett presented Ex-President Crawford with the ex-president badge.

4-6-2 TYPE FREIGHT LOCOMOTIVE.

With a view of bettering operating conditions and reducing operating costs the Delaware, Lackawanna & Western has introduced several powerful new locomotives in both passenger and freight service. In June, 1912, the American Locomotive Company delivered to this company fifteen Mikado type freight locomotives, having a total weight of 312,000 lbs., and a tractive effort of 57,100 lbs., and seven Pacific type passenger locomotives having a total weight of 284,000 lbs. and a tractive effort of 40,800 lbs. These engines have so thoroughly demonstrated the fact that the most powerful locomotives of approved design are also the most economical, that not only have the Mikado and Pacific type engines been duplicated, but seven of the most powerful Pacific type locomotives have recently been built for use in fast freight service. These new locomotives have a total weight of 286,000 lbs., a tractive effort of 43,100 lbs., and a large and well proportioned boiler.

Previous to their introduction, the fast freight traffic was handled by locomotives of the mogul type. The demands of this traffic are constantly increasing, and fast outgrowing the boiler capacity of this type of locomotive. Hauling capacity depends on sustained tractive effort, which in turn depends on boiler capacity. To this end most careful attention was given to the boiler design in the new power.



Powerful Fast Freight Locomotive; Delaware Lackawanna & Western.

The mogul engines have a total weight, engine and tender, of 303,700 lbs., a tractive effort of 29,480 lbs., and a total heating surface of 2,185. The new Pacific type engines have a total weight, engine and tender, of 455,600 lbs., a tractive effort of 43,100 lbs., and a total equivalent heating surface (evaporating heating surface plus 1½ times the superheating surface) of 5, 292. As compared with the mogul type, this is an increase of 50 per cent. in weight, of 47.8 per cent. in power, and 142 per cent. in equivalent heating surface.

The following table shows the results of a test run between Scranton, Pa., and Hoboken, N. J., a distance of 133 miles. Although the men were not familiar with the new engines,

			Percentages In favor of		
	2-6-0	4-6-2	2-6-0	4-6-2	4-6-2
lbs. of coal per engine mile.....	108.0	104.02	100	96.3	3.7
lbs of coal per 1,000 ton miles.....	102.8	75.14	100	73.1	26.9
lbs. of coal per 1,000 ton miles hours	15.13	9.81	100	64.7	35.3
lbs. of coal per 1,000 car miles....	3598.9	2509.0	100	69.7	30.3
lbs. of coal per 1,000 car miles hours	534.5	327.9	100	61.3	38.7
lbs. of water per engine mile.....	837	852.9	100	102.0	2.0
lbs. of water per 1,000 ton miles...	796.8	616.2	100	77.3	22.7
lbs. of water per 1,000 ton mile hours	171.3	80.4	100	68.5	31.5
lbs. of water per 1,000 car miles....	27891.5	20573.8	100	73.7	26.3
lbs. of water per 1,000 car miles hours	4142.1	2688.8	100	64.9	35.1

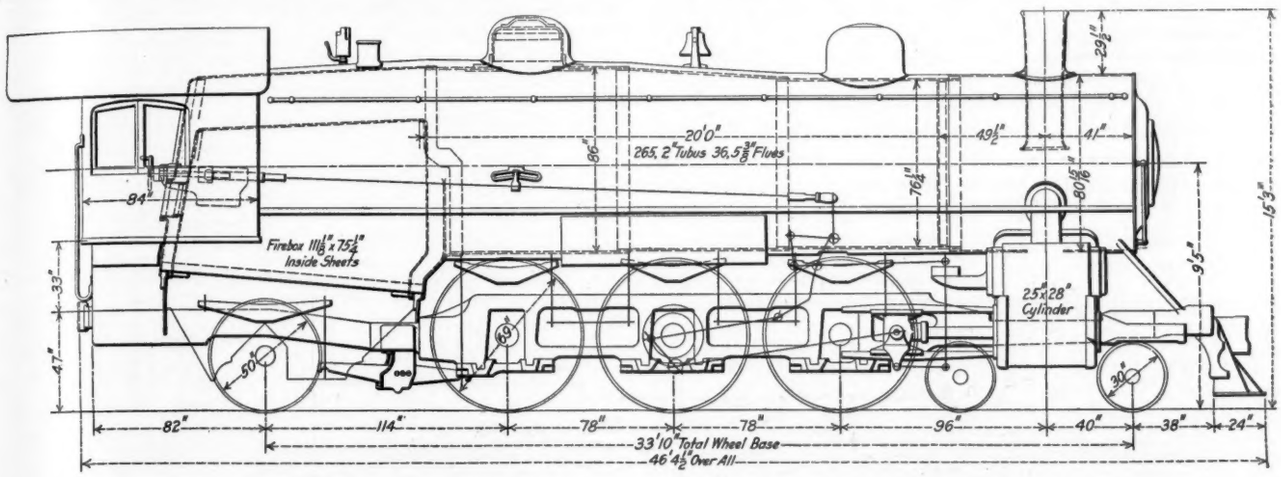
a very decided improvement in coal and water consumption per ton and car mile was obtained. On a train mile basis these new big engines handle their increased train loads on practically the same coal and water consumption as the smaller moguls.

The design is practically a conversion of the hard coal burning Pacific type passenger engine into a soft coal burning Pacific type fast freight engine. The change in fuel necessitated an entirely new design of boiler. With this exception and a reduction of 4 in. in the diameter of drivers and 3 in. in the diameter of the leading truck wheels, it is the same.

free from stuffing boxes or operating levers. This valve is designed so that during periods of standing it can be closed and the water in the hose blown back into the tank, thus leaving the hose free from freezing. This was also devised by Mr. Riegel.

In the following table are given the principal dimensions and weights:

Type	462
Service	Fast freight
Fuel	Bit. Coal
Tractive effort	43,100 lbs.
Weight on drivers	186,500 lbs.
Weight on leading truck	49,000 lbs.



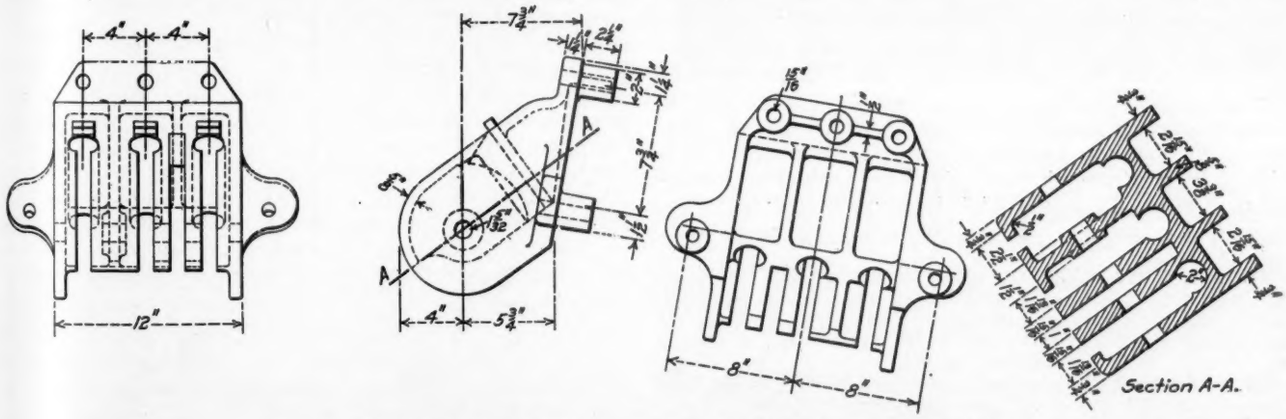
Pacific Type Fast Freight Locomotive; Delaware, Lackawan na & Western.

This means a duplication of almost all the parts that require the most frequent renewals or need to be kept in stock.

The design includes practically all of the improved features perfected by the builders. Among these are: The screw reverse gear, extended piston rods, self-centering valve stem guide, long main driving box, Woodard engine truck, improved outside bearing trailing truck, throttle lever support, and a specially designed draft gear on the engine front end. They also have superheaters, sectional brick arches, and pneumatic fire doors.

The engine decks are provided with a special design of

Weight on trailing truck	50,500 lbs.
Total weight of engine	286,000 lbs.
Total weight of tender	169,600 lbs.
Wheel base, driving	13 ft. 0 in.
Wheel base, total engine	33 ft. 10 in.
Wheel base, total engine and tender	66 ft. 4 in.
Cylinders, diameter and stroke	25 in. x 28 in.
Valve gear	Walschaert
Wheels, diameter of driving	69 in.
Wheels, diameter of truck	30 in.
Wheels, diameter of trailing	50 in.
Wheels, diameter of tender	36 in.
Journals, driving, main	11 in. x 21 in.
Journals, driving others	10½ in. x 13 in.
Journals, truck	6½ in. x 12 in.
Journals, trailing	9in. x 14 in.
Journals, tender	6 in. x 11 in.
Boiler, type	Ex. Wag. top



Riegel Grate Shaker Brackets; Delaware, Lackawanna & Western.

grate shaker brackets shown in the illustration. These are completely enclosed against the dropping of coal and permit the use of the standard tender apron without the necessity of covering the usual openings for the grate shaker brackets. They were designed by S. S. Riegel, mechanical engineer of the railroad.

The tenders are equipped with a low type, quick opening tank well, operating from the ground, and located outside the side sills of the underframe. This keeps the top of the tender

Steam pressure	200 lbs.
Boiler, outside diameter front end	78 in.
Boiler, outside diameter back end	86 in.
Firebox length	111-⅛ in.
Firebox width	75¼ in.
Tubes, number and diameter	265-2 in.
Flues, number and diameter	36-5⅜ in.
Tubes, length	20 ft.
Heating surface, tubes	3769 sq. ft.
Heating surface, firebox	221 sq. ft.
Heating surface, total	3990 sq. ft.
Superheating surface	868 sq. ft.
Grate area	58.0 sq. ft.
Water, capacity of tender	9000 galls.
Coal, capacity of tender	10 tons.

POWERFUL PACIFICS FOR THE ERIE.

The Lima Locomotive Corporation, Lima, Ohio, has recently completed an order of five Pacific type locomotives for use on the New York division of the Erie. These were ordered after considerable experience with experimental engine No. 50,000, built by the American Locomotive Company and purchased by the Erie. The size of the cylinders, length of stroke and diameter of drivers of the new engines are the same as those on No. 50,000, giving them the same tractive effort, *viz.*: 40,630 lbs., but a number of alterations have been made in the boiler. The new design has a firebox 84 in. wide, giving a grate area of 66.6 sq. ft. in place of 59.75 sq. ft. on No. 50,000. The number of tubes has been reduced from 207 to 199 and a straight top instead of a conical type boiler has been specified. The diameter at the front end has been increased from 76⅜ in. to 78 in. but the diameter at the dome is 81¼ in. instead of 87 in. The number of superheater elements is also less, there being 32 in this case as compared to 36 in the experimental engine. In spite of the wider grate the firebox heating surface is less and the total heating surface is 3,813 sq. ft. No. 50,000 has 4,048 sq. ft. evaporating surface.

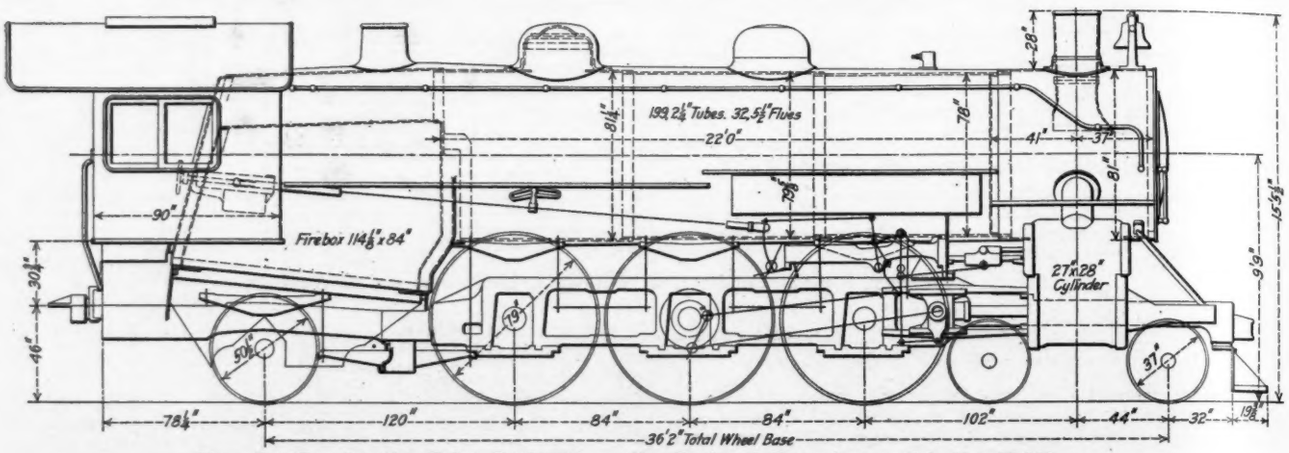
These changes have affected the weights somewhat, but, contrary to what might be expected, it has increased them. No. 50,000 has a total weight of 269,000 lbs. while the new engines weigh 286,825 lbs. in working order. The weight on drivers is 175,725 lbs., an increase of 3,225 lbs. The ratios have also been materially altered as will be seen by comparing the list below and the list published on page 12 of the January, 1912, issue of the *American Engineer*.

The location of the bell ahead of the smoke stack is an innovation that has not been tried before on this railroad. The reason for the change is the belief that a warning can be heard more distinctly when the bell is located in this manner than when it is in the usual position.

The main driving boxes are of the extended design giving a bearing area of 11 in. x 21½ in. The screw reverse gear is used and the locomotives have Baker valve gear. Among the other specialties applied are: Franklin fire door; Chicago flange lubricator; Security brick arch; Ryan and Johnson coal pusher; radial buffers; Leach sanders, Dressel oil headlight; Simplicity bell ringer; Tallmage ash pan; full installation of Tate flexible staybolts; Klinger water gage and U. S. King type piston and valve rod packing. Vanadium steel is used for the frames and rods, and Hunt-Speller iron is employed for piston and valve bushings and rings.

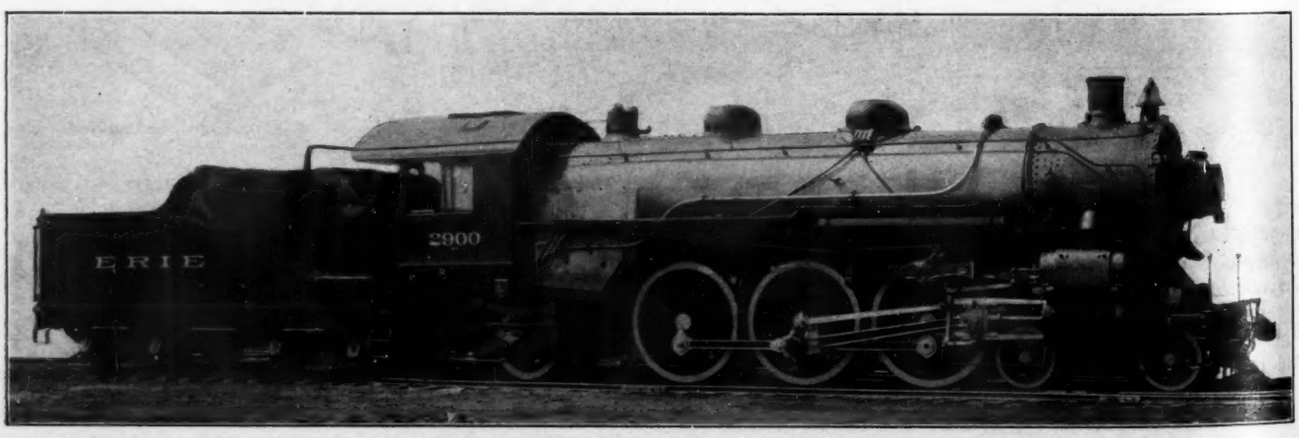
The general dimensions, weights and ratios are given below:

General Data:	
Type	4-6-2
Gage	4 ft. 8½ in.
Service	Passenger
Fuel	Bit. coal
Tractive effort	40,630 lbs.
Weight in working order	286,825 lbs.
Weight on drivers	175,725 lbs.



New Pacifics for the Erie; Designed on the Basis of Experience with No. 50,000.

Weight of engine and tender (loaded)	469,585 lbs.
Wheel-base (driving)	14 ft.
Wheel-base, engine and tender	68 ft. 4⅛ in.
Wheel-base, total	36 ft. 2 in.
Ratios:	
Weight on drivers ÷ tractive effort	4.32
Total weight ÷ tractive effort	7.06
Tractive effort × diameter drivers ÷ heating surface	604
Total heating surface ÷ grate area	57.2
Firebox heating surface ÷ total heating surface, per cent.	5.45
Weight on drivers ÷ heating surface*	33.05
Total weight ÷ heating surface*	53.95
Volume both cylinders, cu. ft.	18.54
Heating surface* ÷ vol. cylinders	286.73
Grate area ÷ vol. cylinders	3.59
Valves:	
Kind	Piston
Greatest travel	6 in.
Outside lap	1⅛ in.
Inside clearance	3-16 in.
Lead	¼ in.



Pacific Type Locomotive for the Erie, Built by the Lima Locomotive Corporation.

Cylinders:	
Kind	Simple
Diameter and stroke	27 in. x 28 in.
Wheels:	
Driving, diameter over tires	79 in.
Driving, thickness of tires	4½ in.
Driving journals, main	11 in. x 21-½ in.
Driving journals, others	11 in. x 13 in.
Engine truck wheels, diameter	36 in.
Engine truck journals	6½ in. x 12 in.
Trailing Truck wheels, diameter	50-½ in.
Trailing Truck journals	9 in. x 14 in.
Boiler:	
Style	Straight
Working pressure	185 lbs.
Outside diameter of first ring	78 in.
Firebox, length and width	114⅛ in. x 84 in.
Firebox plates, thickness	⅜ in.
Firebox, water space sides and back	4½ in.
front	5 in.
Tubes, number and outside diameter	199-2¼ in.
Flues, number and outside diameter	32-5½ in.
Tubes, thickness	.125 in.
Flues, thickness	.150 in.
Tubes, length	22 ft.
Heating surface, tubes and flues	3575 sq. ft.
Heating surface, firebox	208 sq. ft.
Heating surface, arch tubes	30 sq. ft.
Total heating surface	3813 sq. ft.
Superheating surface	1002 sq. ft.
Equivalent heating surface	5316 sq. ft.
Grate area	66.6 sq. ft.
Smokestack, diameter	18.5 in.
Smokestack, height above rail	15 ft. 5½ in.
Tender:	
Wheels, diameter	33 in.
Journals, diameter and length	6 in. x 11 in.
Tank	Water bottom
Water capacity	8500 gals.
Coal capacity	14 tons

*Equivalent heating surface equals total heating surface plus 1.5 times superheating surface.

IMPROVED CAST STEEL TRUCK SIDE FRAMES.—Many mechanical men have long felt that the cast steel truck side frames, designed with the "I" sections now generally used, do not have sufficient strength transversely. A truck frame with channel sections throughout would be best for taking care of the transverse strains, but the foundry difficulties involved in making side frames of this type have so far precluded their use. However, The Buckeye Steel Castings company, Columbus, Ohio, has developed a side frame with the channel sections throughout so that for the same amount of metal the transverse strength is almost three times that of the "I" section of equal area, and at the same time the vertical strength is not decreased. Samples of these designs are on exhibition in Booths 603-605.

YEUNGKONG-KONGMOON LINE, CHINA.—The progress of this line is being retarded by a quarrel about a bridge over the river between Sanui and Kongmoon. There has been a good deal of delay over the building of this structure, and the train does not run any farther than Kongmoon city, which is some four or five miles away from the terminus; that is, the station at Kongmoon. The river runs through this section. An influential body of men signed a petition, and sent it in to headquarters, Canton, asking that the bridge be not allowed, but the reply was that the company was to set to it that the work of constructing the bridge was put through at once, for it was too late to let the prejudices of the few in the vicinity hinder this important work.

MOTOR CAR SERVICE PROPOSED IN CHINA.—It is proposed to institute motor-car service between Lungchow, China, and Nam Kwan, the present northern terminus of the railway from Hanoi. The commencement of this service would be contingent upon the successful operation of a line of launches between Lungchow and Nanning, and would, it is claimed, constitute, next to the extension of the railway to Lungchow, the best solution of the difficulties that hamper and restrict the trade of the port. The proposed service would handle passengers, light freight and parcels, while the heavier and more bulky cargo would continue to come and go by water. The present existing roads would require only moderate improvement to make them serviceable for motor cars. It is doubtful, however, whether this suggestion will receive any consideration from the people of Lungchow.

Conventionalities.

The fact that there is no ball game today will "bear" the amica market tomorrow.

Ask Burt White of the National Boiler Washer Co. the sequel to the yarn of the Superheater pants?

Lost—Diamond bar pin on the pier during the M. M. dance Thursday evening. Please return to enrollment committee booth.

Mrs. Bateman, wife of "Doc" Bateman, and the two young Docs, Huston and Stanley, are scheduled to arrive on the scene to-day.

E. A. Laughlin, vice-president of the Joliet Ry. Supply Co., Chicago, arrived Monday evening and is stopping at the Traymore.

The Davis twins, Nathan H. and Thomas C.—they of steel back fame—spent Friday on the Pier. They are due to return on Monday.

The Superheater white pants had a "day off" yesterday to keep an appointment with the valet. There is some speculation out in the Annex where they will appear next.

On Friday, June 13, 1913, at 9.13 A. M., Chairman Yardley,

Left to right—J. F. Hill, Master Mechanic, Wheeling & Lake Erie, and F. P. Pfahler, Inspector, Interstate Commerce Commission.

of the Enrollment Committee, issued M. M. badge No. 313. The next badge issued was a special guests' badge, No. 1313.

One of the first timers is K. C. Gardner, chief clerk in New York of the Pressed Steel Car Company. Not only is this Mr. Gardner's first convention, but it is his initial visit to this seaside resort.

Mr. and Mrs. W. E. Fowler, Chicago, will be missed at the conventions this year. Mr. Fowler was formerly master car builder of the Canadian Pacific. he is now president of the Fowler Car Company.

P. H. Wilhelm, of the Standard Leather Packing Company, accompanied by Mrs. Wilhelm, reached Atlantic City Thursday. This is Mr. Wilhelm's twenty-third M. M. and M. C. B. Convention, without a miss.

George A. Post, president, and E. H. Walker, vice-president of the Standard Coupler Company, arrived yesterday, and are at the Marlborough-Blenheim. Col. Post, who is president also of the Railway Business Association, speaks optimistically as to public opinion regarding railway matters. He believes there has

been a marked improvement in recent years, and that this is going to continue.

Owing to illness in his family it is greatly regretted that J. F. Graham, assistant general manager of the Oregon-Washington Railroad and Navigation Company, could not this year make the trip to Atlantic City.

The friends of S. K. Dickerson, who for so many years was connected with the Lake Shore and was recently made superintendent of motive power of the Big Four, are extending congratulations on the new job.

Among the convention visitors are Mr. and Mrs. D. J. Gilliland. Mrs. Gilliland was formerly known to those attending the conventions as Mrs. W. P. Appleyard. She and Mr. Gilliland were married on June 2.

Mrs. E. M. Grove and Miss Grove arrived Thursday and, with Mr. Grove, are staying at Chalfonte. The family left Pittsburgh together; but Mrs. Grove and Miss Helen stopped off at Philadelphia to visit Mrs. Grove's mother.

S. F. Bowser, president of S. F. Bowser & Co., is attending the conventions for the first time. This is also true of S. B. Bechtel, assistant general manager, and D. A. Correy, manager of engineering sales of that company.

Ex-superintendent of motive power Peter Maher, of the Chicago & Alton, Bloomington, Ill., who has retired from the active field of railroading, will be unable to attend the conventions this year on account of Mrs. Maher's recent severe illness.

Mrs. Robert Radford, wife of the secretary of the Standard Steel Works Company, is spending a few days here. She and Mr. Radford came over from their summer home at Ocean City on Wednesday. Mrs. Radford expects to return to-day.

E. S. Wortham, manager of purchases and supplies of the Chicago & Alton, fully expected to be in Atlantic City at this time and Mrs. Wortham was to accompany him. At the last moment Mr. Wortham was detained by important business.

M. D. Franey, who was recently promoted to the position of master mechanic on the Lake Shore, with headquarters at Elkhart, Ind., is wearing an unusually broad smile, and has made a thorough job of looking over the exhibits on the pier. He left last night.

Alfred I. du Pont, vice president, and Frank L. Connable, general manager, of the du Pont Powder Company, are visiting the exhibits at the invitation of their friend, J. A. Carey, vice president and general manager of the Standard Stoker Company.

John F. Newhouse, Master Mechanic, Kentucky & Indiana Terminal, Louisville, Ky.

W. E. Dunham, Supervisor Motive Power and Machinery, Chicago & North Western.

J. W. Gardner, general manager, Allis-Chalmers Company, is attending the convention this year as a guest of R. D. Smith, superintendent of motive power, Boston and Albany. This is Mr. Gardner's first convention since 1905, when the Association met at Manhattan Beach.

W. J. Frauendiener, superintendent of shops on the Lake Shore at Elkhart, Ind., has his wife with him this year. He is very much interested in the welding of tubes by electricity, which is being very successfully done on the Lake Shore; he was closely connected with the development of this work at the Elkhart shops.

J. M. Hopkins, president of the Camel Company, who is at the Marlborough-Blenheim, is attending the conventions alone this year. Mrs. Hopkins and J. M., Jr., have been traveling for some time, and are still there. They were accompanied on part of their trip by Mrs. Hopkin's father, A. J. Farley, who is well-known to convention visitors.

Mr. and Mrs. Theodore H. Curtis, Chicago, were unable to attend the conventions this year. Mrs. Curtis has been ill, but is rapidly regaining her health. Mr. Curtis was formerly superintendent of machinery of the Louisville & Nashville. He is now mechanical engineer of the Chicago Association of Commerce board of engineers on smoke prevention and electrification.

Allen Sheldon, manager of the Permanent Exhibition of Railway Supplies in the Karper Building, Chicago, is spending most of his time on the pier seeking whom he may devour. Not having decided until the eleventh hour to come to Atlantic City, he suffered the fate of the rest of the delinquents and had to be content with bunking at one of the smaller hotels—The Lexington.

F. H. Reagan, superintendent of the Delaware, Lackawanna & Western shops at Scranton, Pa., spent Thursday and part of Friday at Atlantic City, returning to Scranton by way of Philadelphia, where he expected to make a short stop. The new shops at Scranton are now about two and a half years old and are operating with exceptionally good results.

George W. Lyndon, Chicago, acting secretary of the association of manufacturers of chilled car wheels, accompanied by E. C. Edwards, secretary of the Association, arrived Thursday and registered at Haddon Hall. Mr. Lyndon has spent most of his active life with the chilled iron wheel. His contributions to the technical press on the subject are sought by the editors. His knowledge of the properly made iron wheel is most thorough and his published efficiency data on the subject is spark-

D. Petrescu, Inspecting Engineer, Roumanian Government Railway.

ling. It is even said by his friends that he put the "pep" in "pepper."

The photograph in Friday morning's *Daily* labeled "Two Master Mechanics of the New York Central & Hudson River" was not intended as a puzzle picture. In some way the second and third lines of the caption were lost. The two master mechanics were M. H. Strauss, of New Durham, N. J., and W. G. Babcock, of High Bridge, N. Y. Mr. Strauss is the one in the Panama hat.

Gaetano Lanza, professor emeritus, Massachusetts Institute of Technology, attended the convention Thursday morning. Professor Lanza is at present conducting special investigations on crank axle design for the Baldwin Locomotive Works at Philadelphia. He is a member of the committee on Main and Side Rods, and has been an associate member of the Association for a number of years.

A. M. White, superintendent of the Manchester Works of the American Locomotive Company, objects, and very properly, to the statement in Thursday's *Daily* that he has not been able to attend the conventions regaularly in recent years. "As a matter of fact." Mr. White writes to the *Daily*, "I have been in attendance for the past twenty-seven years. My first meeting was in 1872, but being general foreman of a railroad shop who at that time was not eligible as a member, I could attend only as a guest."

President Crawford had a rather disturbing incident happen at his home in Pittsburgh day before yesterday. Mr. and Mrs. Crawford spent the summer months at the Country Club, and received advice by wire that it had been burned to the ground. The garage was also destroyed, but Mr. Crawford's machine was removed without suffering damage. He and Mrs. Crawford went West last night to get things straightened up, but expect to return to Atlantic City on Sunday morning.

Mrs. George M. Basford returned home yesterday to officiate at the laying of the corner stone of the Westchester Woman's Club at Mt. Vernon. This club has a membership of over 450, and has a number of sections which are doing active and progressive work along the lines of domestic economy, child training and other subjects of special interest to women. Mrs. Basford is president of the club and has had an exceptionally good administration during the first year of her term, which has still another year to run. The program of the laying of the corner stone includes the name of only one man, and that is the Mayor of Mt. Vernon. The various addresses, the prayer, etc., will all be made by women. Mrs. Basford—according to G. M.—wishes to have it distinctly understood that she is not a suffragette.

P. P. Mirtz is attending his first convention as mechanical engineer of the Lake Shore. He has had all his railroad experience with that road, and during the past year has given a great amount of attention to the problem of locomotive boiler maintenance. Mr. MacBain, the superintendent of motive power, acknowledged his services in connection with the boiler maintenance report at the Thursday morning meeting, but the stenographer did not get the spelling of the name quite right, and it was credited to Mr. Demarest in the *Daily* of June 13, page 1355.

George P. Fox, general foreman car department of the New York Central & Hudson River, at West Albany, reports that the new passenger car shop which was placed in operation during the past year is in good working condition. Six new steel baggage cars have been built during the year, and work is now being started on three new all-steel dining cars. The car shops at West Albany are now handling all of the passenger car work on the New York Central & Hudson River and are splendidly equipped for that purpose.

Although Will Johnson remembers his recent trip abroad with a great deal of pleasure (and incidentally Will says he got some orders over there) he declares that his headlight was not to blame for the accident which occurred on the Shanghai-Nanking railway, in China, in which one death resulted. Will says the following official report was made by the station master to his superior officers: (1) The death named—was smashed by the engine on 3-10-13. (2) Has two sons—and—(3) The death without ticket. (4) The death's fault. (5) The death no relative see. (6) The death is deaf and blind. No cannot say what was.

A. M. Waitt, formerly superintendent motive power of the New York Central, was referred to in one of the issues of the *Daily* as a past vice-president of the M. M. Association. He should have been mentioned as a past president, he having held that office in 1901-1902. Mr. Waitt has missed the last four conventions, being abroad a good deal of the time, but he is here this year, and is at the Marlborough-Blenheim. Few men who have been connected with the railways of the United States have had as good opportunities as he to compare their practice with that of the railways of Europe, and he talks very interestingly of the latter. He expects to make another trip to Europe in a short time. Mr. Waitt is one of the comparatively few American business men who have early made a resolution to retire at a predetermined age and have carried it out, and his

J. L. Meehan, Master Mechanic, Ashland Coal & Iron Company, Ashland, Kentucky.

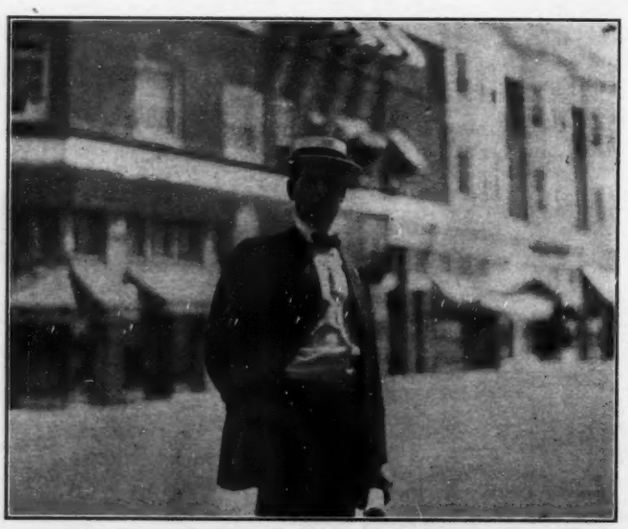
friends are glad to see him at the conventions in which for many years he was an active participant.

John Philpot, foreman of the machine shop of the car department of the New York Central & Hudson River at West Albany, is attending the convention, and expects to return home the latter part of the week. The large amount of all-steel equipment which is being handled at the West Albany shops

C. B. Young, Mechanical Engineer of the Burlington.

has necessitated the addition of a considerable amount of new equipment to the machine shop during the past year. This includes a 10-in. gate shear, plate straightening roll, 5-ft. radial drill, two 21-in. upright drills, one 1½-in. Rich high speed drill, 15-in. throat horizontal punch, 48-in. heavy punch and shear, 24-in. and 36-in. combination punches and shears, and a 3-in. forging machine. Mr. Philpot has been with the New York Central for over 15 years.

E. B. Leigh, president of the Chicago Railway Equipment Company, arrived Friday and is at the Traymore. Arthur



Henry Gardner, Supervisor of Apprentices, N. Y. C. Lines East.

Wyman, assistant to the president of the same company, is expected to arrive this week. Mr. Leigh returned only recently from his vacation. He went from New York by steamer to Texas, and thence to his ranch, which is about 60 miles from San Antonio. Unfortunately, he was able to stay there only two weeks, being called back by a fire in the Franklin plant of the company. He came to Atlantic City by way of New York, where on Tuesday he attended a meeting of the executive committee of the Railway Business Association, of which he is a member. Mr. Wyman was accompanied as far as New York by Mrs. Wyman, and expects after the conventions to return there and go on his vacation.

Professor A. J. Wood, of the Pennsylvania State College, is very enthusiastic over the progress which has been made in railway mechanical work at that institution during the past year. He is accompanied by several of the engineering students who are interested in the railroad course. The college has doubled its attendance in five years, there being now over 2,600 students, a third of whom are in engineering courses. There are about 30 taking the new course in railroad mechanical engineering, the equipment for which is being added to each year. All engineering students of this institution are now required to spend 18 weeks in summer employment by the industries. One railroad has taken on four students for this summer, beginning their special apprenticeship course in this way instead of waiting until after graduation. Professor Wood states that this plan of summer practice is working to the satisfaction of both the college and to the outside interests. The greatest advantage comes

T. E. Hessenbruch, General Inspector, Philadelphia & Reading.

from the discipline received at a period when it counts for the most.

Thomas Aldcorn, general eastern sales agent of the Chicago Pneumatic Tool Company, and Mrs. Aldcorn, celebrated their twenty-fifth wedding anniversary with a dinner at the Marlborough-Blenheim Thursday evening. The affair was a complete surprise to Mr. Aldcorn. Mrs. Aldcorn came down from New York especially for the occasion. The guests present were all connected with the company and included W. O. Duntley, president; Mrs. J. F. Duntley, Miss Blanche Duntley, Fred. D. Johnson, managing director of the company in London; W. P. Pressinger, general manager compressor department; Charles E. Walker, general manager railroad department; C. E. Coates, manager electric tool department; and Mr. and Mrs. J. C. Campbell, Burton H. Tripp, Mrs. L. Summers, Mr. and Mrs. J. W. McCabe, Miss J. McCabe and "Doc" W. H. S. Bateman, C. E. Walker, in behalf of the guests, presented Mrs. Aldcorn with a silver chatelaine bag, and to Mr. and Mrs. Aldcorn a silver service. After Mr. and Mrs. Aldcorn had made appropriate speeches of acceptance, "kiss the bride" was in order. Mrs. Aldcorn faced the ordeal with becoming charmingness.

MASTER MECHANICS' REGISTRATION.

Alling, E. W., M. M., N. Y., N. H. & H., Strand.
Edwards, J. B., Master Mechanic, Col. Newberry & Laurens R. R., Sterling.
Hatch, M. C. M., Supt. Freight Service, D., L. & W. Ry.
Hawkins, B. H., Traymore.
Hedley, F., General Manager, Interborough R. T. Ry., Shelburne.
Hoke, H. A., Asst. Engr. Mech. Engr. Dept., Penna., Chelsea.
Luscombe, J. T., M. M., Big "4."
Machesney, A. G., Lexington.
McGoff, J. H., Mechanical Supt., A. T. & S. F.
Parks, G. E., Asst. Engr., N. Y. C. Lines, Marlborough-Blenheim.
Prendergast, A. P., Supt. M. P., C., H. & D., Shelburne.
Prendergast, Jas. F., M. M., East Broad Top Ry., Haddon Hall.
Sample, N. W.
Smith, C. B., Mechanical Engineer, B. & M., Dennis.
Symons, W. E., Chalfonte.
Tritsch, Chas. M., Supt. Motive Power, W. M., Brighton.
Turner, Amos, M. M., Lehigh Valley, Lexington.
Warnock, H. R., Loco. Dept., Monongahela, Grand Atlantic.

MASTER CAR BUILDERS' REGISTRATION.

Benjamin, C. H., Dean Eng. School, Pierrepont.
Calkins, A. E., Asst. to Supt. Rolling Stock, N. Y. C. & H. R., Traymore.
Cleaver, F. C., Supt. Motive Power, Rutland, Marlborough-Blenheim.
Hoke, H. A., Asst. Engineer Mech. Engr. Dept., Penna.
Luscombe, J. T., M. M., C. C. C. & St. L.
Prendergast, A. P., Supt. Motive Power, C., H. & D., Shelburne.
Robider, W. J., M. C. B., Cent. of Georgia, Chelsea.
Schroyer, C. A., Supt. Car Dept., C. & N. W., Traymore.
Staley, H. F., M. M., Caro., Clinchfield & O., Traymore.
Symons, W. E., Chalfonte.
Thomas, F. H., Vice-Pres. & General Manager, Bellefonte Central, Craig Hall.
Tritsch, C. M., Supt. M. P., Western Maryland, Brighton.
Turner, Amos, M. M., Lehigh Valley, Lexington.

M. M. GUESTS.

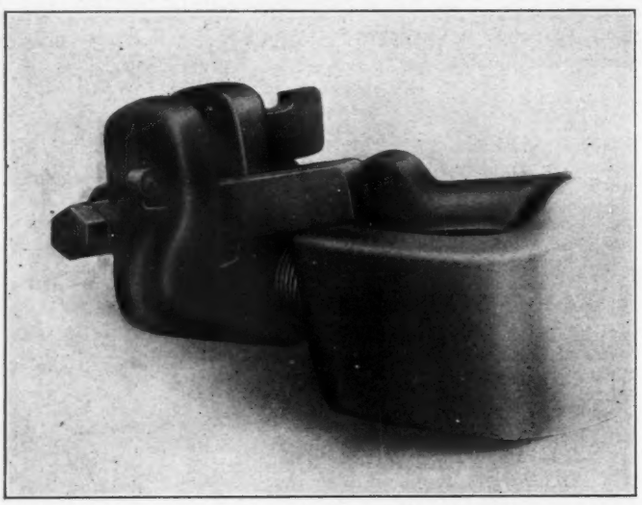
Anderson, G. S., For. Elect., Penna.
Anderson, J. B., Cihef Clerk S. M. P., Penna., Runnymede.
Baird, L. H., C. Clk., Penna., Chalfonte.
Barnes, P. H., G. F. M., B. & O.
Barton, E. O., Gen. For., Penna., Chalfonte.
Barwis, C. W., Asst. Supervisor, Penna., Princess.
Beall, Ecard, Channell.
Beall, J. W., Inspr. Shops M. P. Dept., B. & O., Channell.
Bower, W. C., N. Y. C. & H. R. R., Shelburne.
Boyer, C. W., Asst. For. Erecting Shops, Pa., 122 Seaside Ave.
Buchsbaum, F. J., Enginehouse For., Penna.
Burke, H. C., Gang For., B. & O., Wittle.
Carrall, J. T., Asst. Guil. S. M. P., B. & O., Marlborough-Blen-
Clare, Jas. E., Asst. Foreman, Penna.
heim.
Collins, C. R., Chief C. T. Time Clerk, Pittsburgh Div. Penna., Shelburne.
Corkill, L., Foreman, C. R. R. of N. J., Lyric.
Cotton, W. A., Chief Clerk to Gen. Mech. Supt., Erie, Marlborough-Blenheim.
Cromwell, H. C., Draughtsman, B. & O., Kenderton.
Cross, D. W., M. M., T., St. L. & W.
Curran, D. D., Pres., N. O. & N. E., Marlborough-Blenheim.
Demarest, G. L., Chief Clerk, C. R. R. of N. J., Islesworth.
Dildine, J. A., Chief Clerk M. P. Dept., Penna. Lines, West, Traymore.
Disharoon, L. T., Fireman Blacksmith Shop, N. Y., P. & N., Haddon Hall.
Dixon, B. R., Air Brake Instructor, Penna., Haddon Hall.
Down, William E., Gang Foreman, Camden Terminal Division, Penna. R. R., Bonber.
Dupell, R. E., Rd. For. of Engines, W. J. & S.
Eliot, H. H., Jr., Motive Power Insp., Penna.
Engard, A. C., U. S. Navy, Bothwell.
Erb, Chas. W., S. Keeper, Penna.
Filskov, T., Raritan River, Worthington.
Forrester, Geo. W., Traffic Manager, Piedmont Northern, Chalfonte.
Fulmor, J. H., M. M., W. J. & S., Pennhurst.
Gainey, J. J., M. C. B., C. N. O. F. P., Chalfonte.
Gearhart, John, For. P. A., Penna., Dunlop.
Gibson, Edward, Foreman, P., B & W.
Gority, John, Foreman Machine Shop, Penna., Seaside.
Grant, H., For., Penna., Iroquois.
Griest, E. E., Asst. M. M., Penna. Lines.
Heimmelberger, C. M., Supt., Raritan River, Worthington.
Henlig, E. L., For., So., Lexington.
Henry, H. B., Asst. to Director of Purchases, So. Pac., Chelsea.
Hill, Clarence, Chief Clerk Accts., Penna., Shelburne.
Hughes, B., P. A., L. & N. E.
Hutson, H. M., M. M., P. & O., Lexington.
Jewett, Edward, Asst. Ch. Eng., Brighton.
Kauffman, G. B., Passenger Agent, Atlantic City.
Kelly, G. W., Foreman, C. R. R. of N. J., Worthington.
Kendig, W. M., Inspt., Penna., Jackson.
Kilborn, James E., Purch. Agt., Rutland Transit Co., Shelburne.
King, J. A. C., Draughtsman, Penna.
Kreider, Charles N., General Boiler Inspector, P. & R.
Lindner, W. C., Foreman Car Inst., Penna., Traymore.
Little, David, Foreman Painter, Penna., Rudolf.
Loux, J. P., M. M., L. V., Lexington.
Martin, C. W., Genl. Air Brake Inspector, Penna. R. R.
McCausland, K. B., For., Penna., 1709 Atlantic Ave.
McGrath, C. H., Chief Clerk, So. Pac., Traymore.
Miller, Geo. A., Jr., F. E. C. Ry., Sterling.
Milner, B. B., Asst. M. M., P., B. & W., Haddon Hall.
Montgomery, Wm. H., Traveling Freight Solicitor, Penna.
Morkland, W. H., Penna., Seaside.
Morley, E. S., Asst. Chief Clerk, Penna., Shelburne.
Morningstar, W. E., Draughtsman, B. & O., 163 Ocean View Ave.
Morton, R. C., Draughtsman, B. & O., Kinderton.
Mueller, J. R., P. A., Hocking Valley, Marlborough-Blenheim.
Munro, R. C., Pur. Dept., So. Pacific, Louvan.
Olhausen, J. T., Supt. Phila. Div., B. & O.
Olhauser, Joseph, B. & O.
O'Neal, J. E., Car Foreman, D. & H., Chalfonte.
Oren, J. W., Foreman Engine House, N. Y., P. & N., Haddon Hall.
Pearce, C. B., For., Penna.
Pease, O. D. A., Test Dept., Penna., Shelburne.
Porter, S. C., Traffic Mgr., Old Dominion Steamship Co., Chalfonte.
Potts, S. C., Test Dept., Penna., Shelburne.
Portner, W. H., Supt. Car Shops, O. & C., New American.
Pratt, P., Asst. Eng. House For., W. J. & S
Purt, Arthur F., Penna. R. R., Devonshire.
Read, W. P., W. J. & S.
Reinhart, E., Time Keeper, Cornwall, De Lacey.
Riley, S. B., Dist. For., Kansas City So., Monticello.
Rittenhouse, J. R., Supt. Pullman Co., Brighton.
Roche, John J., Foreman Blacksmith.
Rommel, Charles, Eng. House Foreman, P. & R.
Rommel, C. T., Spec. Insp. M. F. Dept., B. & O., Craig Hall.
Roop, S. H., W. J. & S.
Sandhas, H. L., Air Brake Inst. & Insp., C. R. R. of N. J., Lexington.
Scanland, N. B., M. M., Maryland & Pa., Dunlop.
Scott, Harry C., Gen. Mach. Foreman, Penna., Fredonia.
Scott, G. E., Asst. Purch. Agt., M. K. & T., Shelburne.
Severn, A. B., Draughtsman, B. & O., Kenderton.
Shaffer, M. L., For., Penna., Dunlop.
Sheldon, R. D., Engine House Foreman, P., B. & W., Chalfonte.
Smith, E. W., For., Penna., Princess.
Snyder, J. C., Asst P. A., N. Y. C. & H. R., Marlborough-Blenheim.
Sproul, S. V., Road For. of Engines, Penna. Lines.
Southerland, Walter S., Chief Accountant, Penna.
Staples, O. L., Genl. For., Penna., Islesworth.
Steen, W. J., Traveling Engineer, Penna.
Stofflet, H. A., E. W., P. & R., Bouvier.
Strickler, Lyman, Train Dispatcher, Penna.
Thalheimer, N. C., Draughtsman, B. & O., Kenderton.
Thomas, Francis E., Craig Hall.
Thomason, E., Gen. Manager, Piedmont Northern Lines, Chalfonte.
Thomson, McLeod, 43 Aberdeen Pl.
Torback, F. S., For. M. P. Dept., B. & O., Wittle.
Turner, J. A., Asst. to P. A., Southern.
Van Buskirk, E. C., Gen. For., Wash. Terminal.
Walker, J. W., Gen. Air Brake & Steam Heat Insp., Western Penna. Division, Iroquois.
Watkins, G. H., Asst. M. M., Penna., Haddon Hall.
White, Geo. D., S. Keeper, Penna.
Wilbur, Rollin H., Vice-Pres. & Gen. Manager, Lehigh & New England, Shelburne.
Wilkins, O. P., Foreman, Norfolk & Western.
Wilson, Amos, Special Instructor, D. L. & W.
Wilson, S. E., Traveling Fireman, D., L. & W.
Witherspoon, W. H., Foreman, C. R. R. of N. J., Edison.
Wine, W. E., Ch. Drftsman, Atlantic Coast Line.
Wyun, E. P., Piecework Foreman, P. & R. Loco. Shop.
Young, J. B., Chemist, P. & R.

BUDA-ROSS ELECTRIC HEADLIGHT.

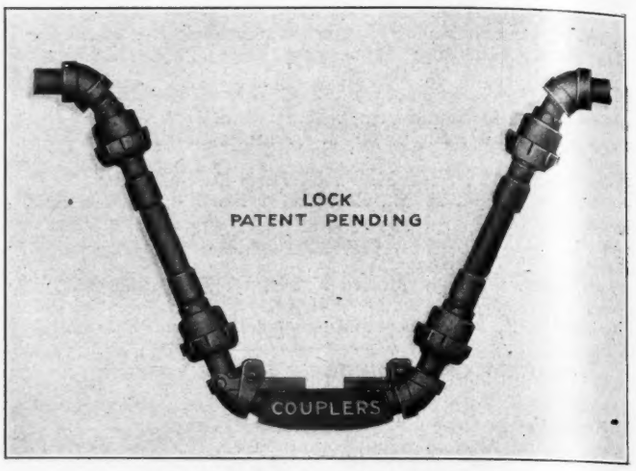
The Buda Company, Chicago, has recently formed a headlight department for the manufacture and sale of the **Buda-Ross** electric headlight. Mark A. Ross, who has been identified with the electric headlight industry for the past 16 years, is in charge of the department and is assisted by Harry P. Bayley and John Eberhart. One of the new headlights is being exhibited at the Buda Company's booth.

LOCK FOR STEAM HOSE COUPLINGS.

With the high pressures frequently required on the steam heat train line there is an increasing tendency for the couplers to rise from their normal position and leak. The Greenlaw Manufacturing Company, Boston, Mass., is exhibiting a locking device to prevent this trouble. It is shown as applied to the design of flexible metallic hose manufactured by this company and consists of a lever attached to the hose elbow which, when in position, bears firmly on the top of the opposite coupler head. The lever is held in place by a key fitting through a slot above it. When it is desired to disconnect the hose, the key can be quickly released, the lever raised and the coupler head is freed for uncoupling. While this lock is shown in the illustration as in use with two metallic hose, its operation is equally efficient if one is a rubber hose. It is arranged to operate with any type of coupler head.



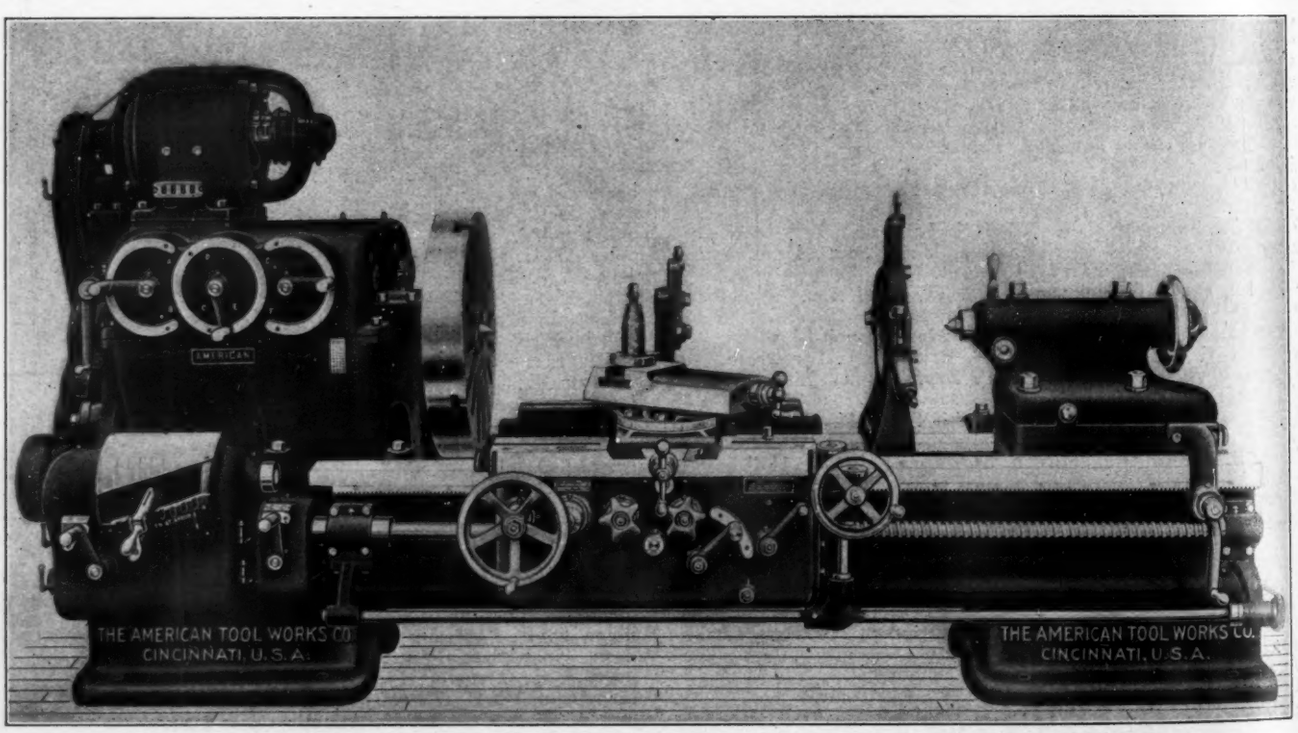
Locking Device for Steam Hose Couplings.



Steam Heat Line Couplings Locked in Place.

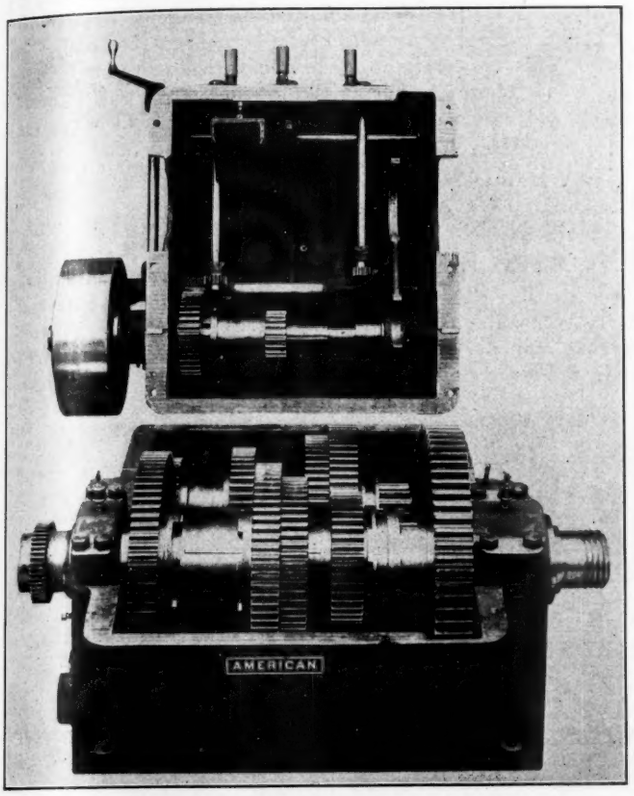
TWELVE-SPEED, GEARED HEAD FOR LATHES.

The American Tool Works Company, Cincinnati, Ohio, is exhibiting a new 12-speed, geared head for application to its 30 in. and 36 in. lathes. This head is of the compound, back-geared type and is furnished for either belt or motor drive. Twelve spindle speeds are obtainable, ranging from 6 to 260 r. p. m., by the operation of levers on the front of the head; an index plate located on the head indicates how to obtain the various speeds. The maximum gear ratio is unusually high, being 43.3 to 1. The head is heavily con-



Heavy Duty 36-in. Lathe Driven Through a Twelve-Speed Geared Head.

structed and an important feature is its simplicity, as only 12 gears are used to produce the 12 spindle speeds. The gears are cut from the solid with special cutters, are of wide face and coarse pitch and are tested for accuracy on special machines; the teeth of the slip gears are machine



Interior of Twelve-Speed Geared Head.

rounded to facilitate meshing. The driving pulley runs on a bronze bushed steel sleeve, thus relieving the driving shaft of all belt strain. The pulley has an improved automatic oiling system and a friction clutch controlled by a drop lever is provided, by means of which the gears in the head can be stopped or slightly moved without interfering with the driving belt, thus permitting speed changes to be easily made. The head-stock can be quickly converted into a motor drive at any time after installation by simply removing the pulley drive unit, placing a motor on top of the head-stock, and connecting it to the driving shaft through a spur gear.

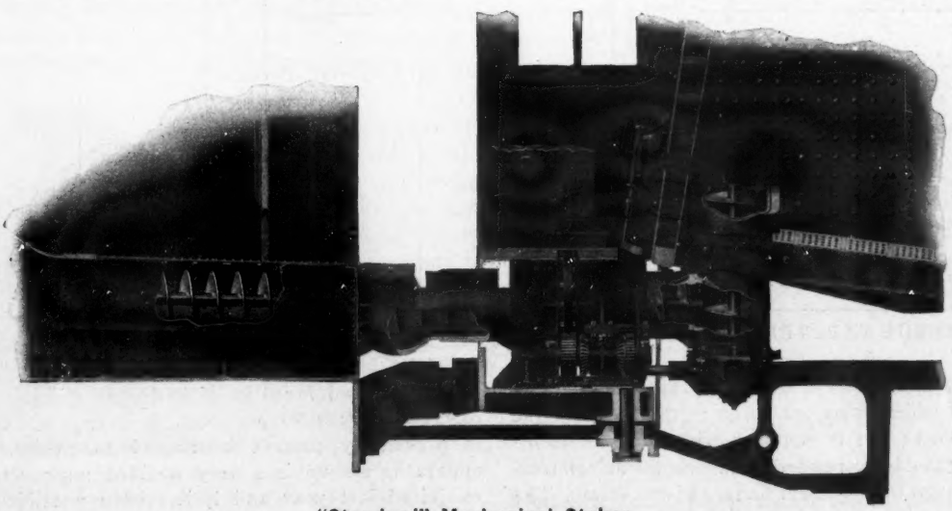
THE "STANDARD" MECHANICAL STOKER.

One of the exhibits that is attracting general attention is a new design of mechanical stoker being shown by the Standard Stoker Company, New York. It provides for conveying the fuel from the tender by means of a screw conveyor located in a trough under the floor of the coal space. This trough is covered by a grating with 6-in. openings and by sectional covers each about 15 in. in length. The conveyor carries the fuel under the deck of the cab and discharges to a similar vertical conveyor which rises through the grates and discharges the fuel at a point about 12 in. above the grate level at the center of the back of the firebox. The section of the stoker projecting above the grates and in the fire bed is protected by a ring of a special quality of iron which has great heat resisting properties. This ring is also further cooled by the admission of exhaust steam from the small engine driving the stoker which is discharged through passages on its interior, emerging at the top. Arrangement is made for the ready renewal of this ring, if it becomes burned, without inconvenience or delay.

Six steam jets from the ends of four small pipes projecting through an opening in the back water leg, distribute the coal from the top of this conveyor to the various parts of the fire bed. These jets are intermittent in their action, being controlled by a specially constructed valve which, by its reciprocation, allows a small amount of high pressure steam to escape through each of the four pipes successively. The pressure in each pipe can be controlled by means of a globe valve, permitting full control of the distribution. The reciprocating valve and its immediately associated parts are the only parts of the stoker that are located in the cab.

The machine is driven by a small reciprocating engine secured to the outside of the frame on the left side of the locomotive immediately under the cab. The main driving shaft from this engine drives a short intermediate shaft, through beveled gears, which is connected by reduction gearing to the conveyors, both horizontal and vertical. An eccentric operated from the main shaft provides a reciprocating motion for the distributing jet control.

An interesting feature of the design is the arrangement for providing a flexible motion in the conveyor trough between the locomotive and tender. This is done by means of a double ball and socket arrangement and the use of universal joints on the shaft of the screw. By this means the horizontal conveyor, complete, is driven from one point which is under the cab deck and convenient for inspection.



"Standard" Mechanical Stoker.

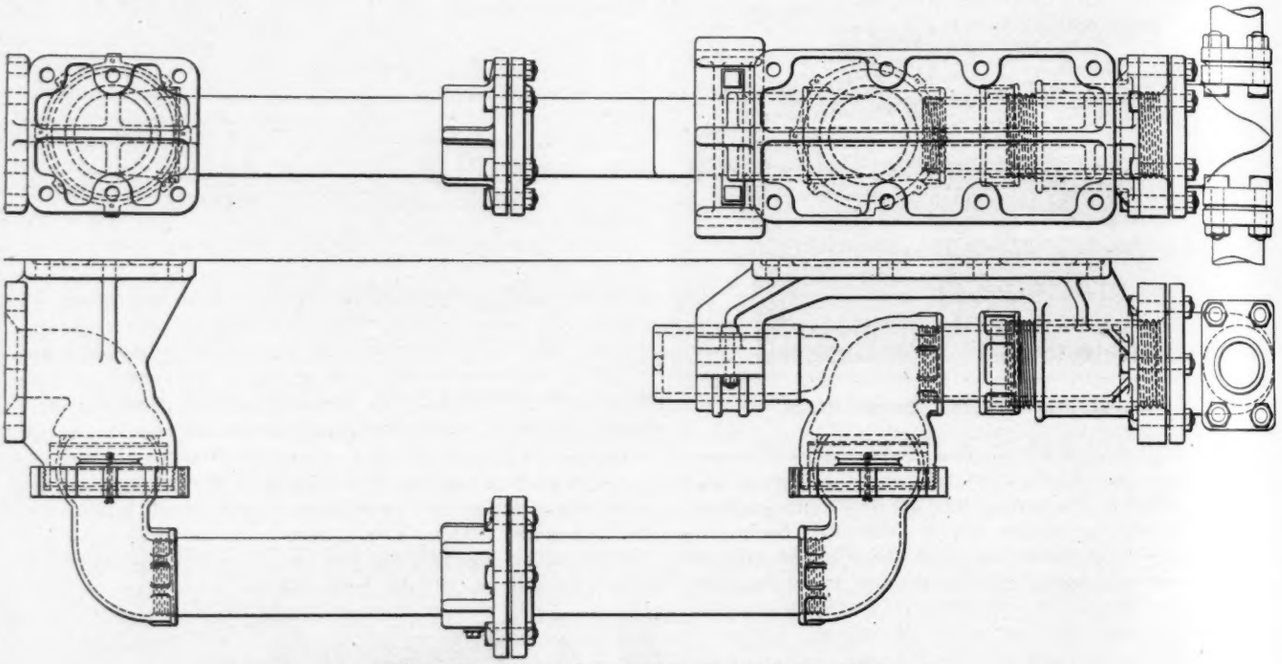
Any coal that will pass through a 6-in. opening, which will permit it to enter between the flights of the conveyor, can be handled by the stoker. Large pieces will ,of course, become somewhat crushed when it is forced to the vertical screw, and

the fuel as discharged from the top will be comparatively small pieces which are easily handled by the steam jets. The intensity of the steam jets is under full control of the fireman.

A stoker of this design is now in experimental use on a large consolidation locomotive on the New York Central & Hudson River. Experience up to the present time has indicated its success.

FRANKLIN WATER JOINT.

The Franklin Railway Supply Company, New York, is exhibiting a flexible metal connection for the injector supply between the engine and tender. This device is shown in the illustration and consists of two ball joints connected by suitable lengths of pipe, one of the joints being rigidly mounted on either the engine or the tender while the other is so mounted as to take care of all movement. Only one of these connections is used on a locomotive, as it is made sufficiently large to supply enough water for both injectors. In order to reduce wear to a minimum, the connection is placed directly under the drawbar, this being the point where the least movement is required. A flanged joint is used to connect the two pieces of pipe through which the water passes between the ball joints. A device of this kind will readily commend itself to motive power officers, particularly on roads which operate in cold climates where much trouble is often experienced with hose connections in the winter months.



Franklin Water Connection for Injector Feed.

SPRAGUE ELECTRIC HOIST.

Some new features in hoist construction are incorporated in the one-ton hoist which is on exhibition in the booth of the Sprague Electric Works. It is equipped with a 1½ h. p. direct current motor and is suspended from a motor driven trolley carriage which runs on the lower flanges of an I-beam. The motor is controlled by means of a special foundry controller intended to give the very slow speeds which are necessary to satisfactory foundry operation; this speed control may also be used to advantage for any work which requires delicate manipulation such as setting driving wheels and heavy castings in lathes. One of the interesting features of the machine is that which provides for the entire mechanism being completely enclosed. There is nothing exposed outside the frame except the wheel which operates the controller shaft, the controller itself, the rheostat and all other parts being completely protected. An automatic safety device prevents the hook from over-running when it reaches the upper limit of its travel. The controller cylinder becomes disengaged from the operating wheel and returns to the "off" position, although the operating wheel may be held in the "on" position. This concentrates all the electrical contacts within the controller itself, eliminating the necessity for additional and external contacts to break the circuit when the limit operates.

OXYGEN GENERATORS.

The use of oxygen in this country for welding and cutting operations is growing at such a rapid rate that the several large companies engaged in making commercial oxygen are having difficulty to keep up with the demand. Compared with foreign countries, however, the consumption of oxygen by railways in this country is comparatively small. It is stated that one railway in France uses over 2,500,000 cu. ft. of oxygen a year and in England practically every railroad has oxy-acetylene or oxy-hydrogen installations in nearly every repair shop.

The future prospects in this direction makes the improved oxygen generating apparatus that is being exhibited by the International Oxygen Company, New York, of special interest at this time. This company has on exhibition its standard type of generator which will produce 3½ cu. ft. of oxygen and 7 cu. ft. of hydrogen a kilowatt hour. The oxygen exceeds 99 per cent. in purity while the hydrogen is practically perfect in regard to purity. The present apparatus shown is a very decided improvement over that exhibited last year and it has been possible to reduce the size of the generator by one-third.

This type of apparatus is entirely automatic in its operation and will operate for days and months without requiring repairs or change of parts, or even to be cleaned. The gases can be carried through a pipe to any part of the shop or yard and the oxygen can be compressed in cylinders for use at distant points, if desired.

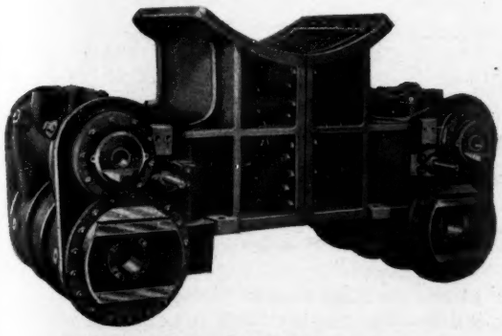
FINISHING TOOL FOR BALL ENDS OF SUPERHEATER UNITS.

After the ball ends of the inner units of superheaters become rusted they are liable to leak and they deteriorate rapidly under the cutting action of the superheated steam if they are neglected. To facilitate the repairs to the ball ends, the Draper Manufacturing Company, Port Huron, Mich., has developed a tool which is shown in the illustration and which it is exhibiting at the conventions. The tool consists of two parts, a cup tool and a ball reamer for the seat and as shown in the illustration, may be operated by a hand brace. It can also be used in a pneumatic drill and it is claimed that it cuts a perfect ball joint and that no special skill is required by the operator to do the work successfully.

Tool for Finishing the Ball Ends of Superheater Units.

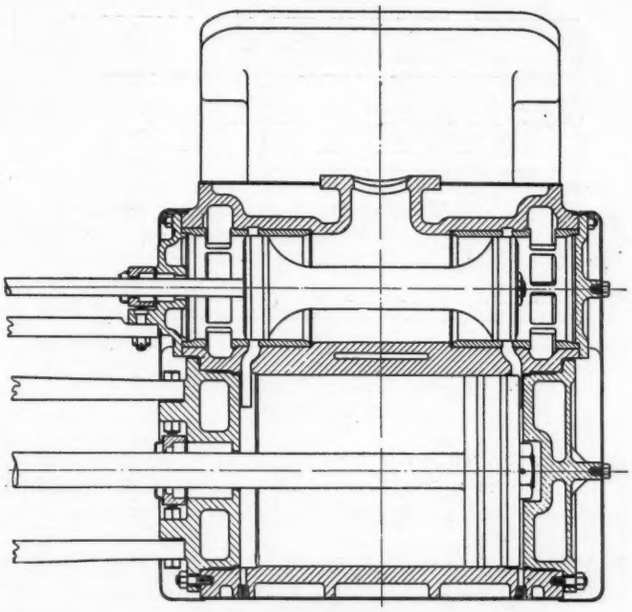
ALFREE CYLINDERS WITH PISTON VALVES.

The Hobart-Allfree Company, Chicago, is exhibiting a ¼ size model of a locomotive equipped with the Allfree cylinders arranged to work with piston valves. The valves on one side of the engine are operated by the Walschaert gear and on the other by the Baker gear to show the adaptability of either gear to the operation of the compression valve. As in previous designs of the Allfree cylinders the main valve controls the admission, cut-off and release in the same manner as in all cylinders, but with an increase in the exhaust lap which holds the steam in the cylinders longer so that more work may be obtained from greater expansion. The compression valve opens for release simultaneously with the main valve which not only permits of more expansion but gives greater freedom of exhaust.

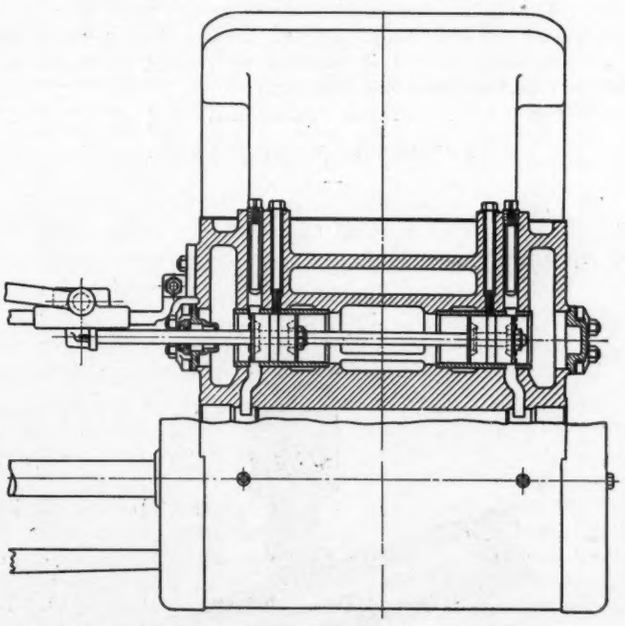


Allfree Cylinders with Piston Valves.

The most important work of the compression valve comes after the main valve has closed. This point is usually the beginning of compression, but the compression valve is timed to remain open after the main valve closes and may be set to give any desired amount of compression without disturbing the events of the main valve. Having compression under control, it is a matter of adjustment to reduce it to only that amount which is necessary as a cushion for the reciprocating parts, when the direction of their movement is reversed. This practically eliminates the effective resistance of compression and the equivalent in power becomes available for drawbar pull. This also permits of reducing the clearance space between the piston and the valves.



Section Through Main Valve, Alfree Cylinder.

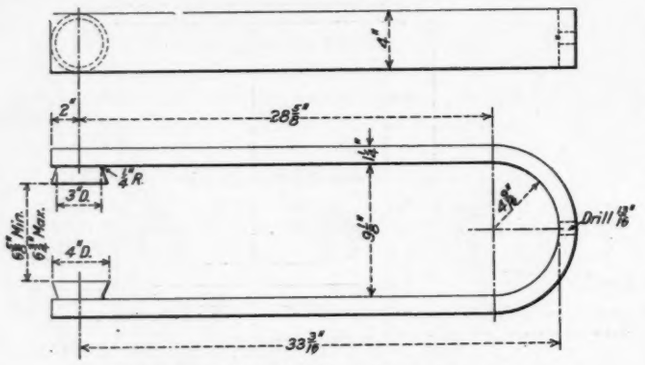


Section Through Compression Valve, Allfree Cylinder.

The use of the compression valve will allow an increase in the ratio of expansion, as the reduced clearance space changes the proportion of the actual volume of steam admitted at any given cut-off. The illustrations show sections through the main valve and the compression valve.

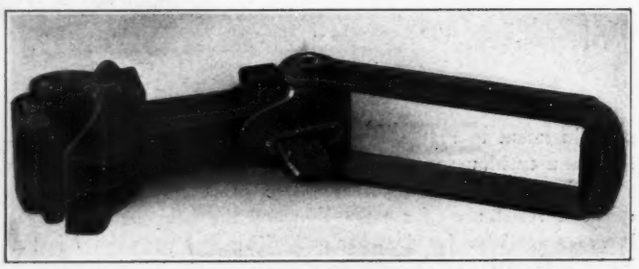
SWIVEL DRAWBAR YOKE.

A recent development in drawbar yokes is being exhibited by McCord & Company, Chicago. One of the illustrations shows a cast steel yoke and its accompanying sleeve keyed



Forged Yoke for McCord Keyed Flexible Drawbar Arrangement.

to a drawbar, while the drawing shows a later development of the yoke in wrought iron. The cast steel sleeve is held to the drawbar by a key and the yoke is so constructed that



Key Attached Swivel Drawbar Yoke.

it swivels on two discs. By this means rivet connections are eliminated and it is possible to remove the drawbar without taking down the draft gear.

AUTOMATIC TILTING LAMP.

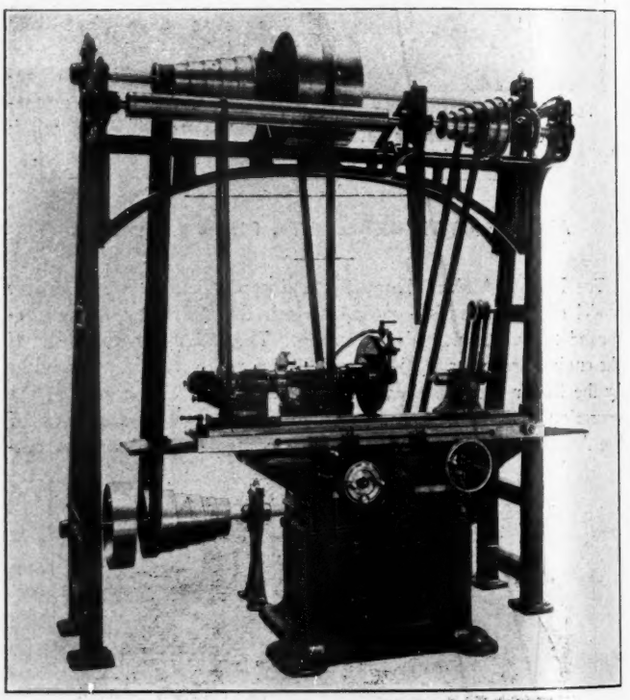
The automatic, self-tilting lamp, which is shown in the illustration, is manufactured by the Cooper Hewitt Electric Company, Hoboken, N. J., and is similar in most respects to

Cooper-Hewitt Automatic Tilting Lamp.

the other mercury vapor lamps manufactured by that company. It has, however, a small solenoid or magnet between the holder and the auxiliary and when the circuit is closed, the current flows through the solenoid which tilts the tube for lighting. This makes the automatic lamp particularly desirable for use in places where it would be difficult to reach the lamp to tilt it by hand. The automatic operation insures the relighting of the lamp should there be a momentary interruption of the current supply. In places where the bluish-green light given out by the mercury vapor lamp is not desired, this company is now prepared to fit their lamps with a device known as a light transforming reflector. This is a parabolic rhodomain reflector which takes the place of the standard white glazed reflector and is based on the phenomenon of florescence. This reflector transforms the light to a white with a slight rosy tint.

UNIVERSAL GRINDING MACHINE.

The Morse Twist Drill & Machine Company, New Bedford, Mass., is exhibiting a universal grinding machine with automatic feed and arranged for motor drive, as shown in the illustration. This machine will take wheels 12 in. in diameter and 3/8 to 3/4 in. thick, and 7 in. in diameter and 3/8 in. thick. The wheel spindle is hardened and ground and runs in phosphor bronze boxes, which are arranged for adjustment for wear. The wheel slide is graduated in degrees and is adjusted by a hand wheel and dial, the latter having graduations to express thousandths of an inch on the diameter of the work. The travel of the table is automatic and the reversing is controlled by dogs; the table can be



Universal Grinder Equipped for Motor Drive.

stopped at any point by a lever on the front of the machine, leaving it free to be moved by a hand wheel. A feed box, arranged conveniently on the machine, provides a means, through a lever, of instantly changing the traverse feed from a roughing to a finishing feed. The usual pump and piping are provided for wet grinding; the pump tank is hung on pivots to provide a ready method of cleaning. The overhead apparatus is provided with two shipper arms, one of which controls the drive for the wheel and the feed, and the other the work and the pump. The wheel feeds range from 1,025 to 3,333 r. p. m. in six changes. The weight of the machine is 3,750 lbs., and the floor space occupied is 50 in. by 119 in.